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A. D. MELVIN, CHIEF OF BUREAU.

THE NEMATODES PARASITIC IN THE ALIMENTARY
TRACT OF CATTLE, SHEEP, AND
OTHER RUMINANTS.

BY

B. H. RANSOM, PH. D.,
Chief of the Zoological Division.



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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., September 23, 1910.

SIR: I have the honor to transmit herewith, and to recommend for publication as a bulletin of this Bureau, a manuscript entitled "The Nematodes Parasitic in the Alimentary Tract of Cattle, Sheep, and Other Ruminants," by Dr. B. H. Ransom, chief of the Zoological Division of this Bureau. The purpose of the paper is to supply data heretofore unpublished or otherwise not readily available, which will enable zoologists, veterinarians, and other investigators to identify nematodes belonging to known species that may be found in the alimentary tract of ruminants. All of the parasites in question, among which are included such important forms as the stomach worms, hookworms, and nodular worms, are briefly described, and the illustrations show the characteristics of the more important species.

Respectfully,

A. D. MELVIN,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

	Page.
Introduction.....	13
List of nematodes occurring in the alimentary tract of ruminants.....	13
Methods of collecting and preparing specimens.....	15
Structure of nematodes parasitic in the alimentary tract of ruminants.....	16
Form.....	16
Size.....	17
Cuticle.....	17
Digestive system.....	18
Mouth.....	18
Esophagus.....	18
Intestine.....	19
Anus.....	19
Nervous system.....	19
Reproductive system.....	19
Male reproductive system.....	19
Spicules.....	20
Bursa.....	20
Female reproductive system.....	22
Vulva.....	22
Vagina.....	22
Uterus and ovary.....	23
Eggs.....	23
Description of nematodes parasitic in the alimentary tract of ruminants.....	24
Key to families of Nematoda.....	24
Family Ascaridæ.....	24
Genus <i>Ascaris</i>	24
Key to species of <i>Ascaris</i>	25
<i>Ascaris ovis</i>	25
<i>Ascaris vitulorum</i>	25
Family Strongylidæ.....	26
Key to subfamilies of Strongylidæ.....	26
Subfamily Strongylinæ.....	26
Key to genera of Strongylinæ.....	26
Genus <i>Agriostomum</i>	27
<i>Agriostomum vryburgi</i>	27
Genus <i>Monodontus</i>	27
Key to species of <i>Monodontus</i>	28
<i>Monodontus trigonocephalus</i>	28
<i>Monodontus phlebotomus</i>	31
<i>Monodontus longecirratus</i>	34
Genus <i>Chabertia</i>	35
<i>Chabertia ovina</i>	35
Genus <i>Eucyathostomum</i>	38
Key to species of <i>Eucyathostomum</i>	38
<i>Eucyathostomum longesubulatum</i>	38
<i>Eucyathostomum spinulosum</i>	40

	Page.
Description of nematodes parasitic in the alimentary tract of ruminants—Con.	
Family Strongylidæ—Continued.	
Subfamily Strongylinaæ—Continued.	
Genus <i>Æsophagostomum</i>	40
Key to species of <i>Æsophagostomum</i>	41
<i>Æsophagostomum columbianum</i>	41
<i>Æsophagostomum radiatum</i>	44
<i>Æsophagostomum venulosum</i>	46
Subfamily Metastrongylinaæ.....	47
Key to genera of Metastrongylinaæ.....	47
Genus <i>Hæmonchus</i>	49
Key to species of <i>Hæmonchus</i>	50
<i>Hæmonchus contortus</i>	50
<i>Hæmonchus longistipes</i>	54
(? <i>Hæmonchus</i>) <i>bispinosus</i>	54
Genus <i>Ostertagia</i>	54
Key to species of <i>Ostertagia</i>	55
<i>Ostertagia ostertagi</i>	56
<i>Ostertagia circumcincta</i>	59
<i>Ostertagia trifurcata</i>	62
<i>Ostertagia marshalli</i>	62
<i>Ostertagia occidentalis</i>	67
<i>Ostertagia mentulata</i>	68
<i>Ostertagia brigantiaca</i>	69
Genus <i>Cooperia</i>	69
Key to species of <i>Cooperia</i>	70
<i>Cooperia curticei</i>	71
<i>Cooperia punctata</i>	74
<i>Cooperia oncophora</i>	77
<i>Cooperia pectinata</i>	81
Genus <i>Nematodirus</i>	82
Key to species of <i>Nematodirus</i>	82
<i>Nematodirus filicollis</i>	82
<i>Nematodirus spathiger</i>	85
<i>Nematodirus digitatus</i>	85
Genus <i>Trichostrongylus</i>	86
Key to species of <i>Trichostrongylus</i>	87
<i>Trichostrongylus instabilis</i>	88
<i>Trichostrongylus colubriformis</i>	90
<i>Trichostrongylus probolurus</i>	90
<i>Trichostrongylus vitrinus</i>	92
<i>Trichostrongylus extenuatus</i>	94
<i>Trichostrongylus capricola</i>	96
Species of Metastrongylinaæ of uncertain position.....	98
<i>Strongylus ventricosus</i>	98
<i>Strongylus fordii</i>	99
Family Filariidæ.....	99
Key to genera of Filariidæ.....	100
Genus <i>Gongylonema</i>	100
Key to species of <i>Gongylonema</i>	100
<i>Gongylonema scutatum</i>	100
<i>Gongylonema verrucosum</i>	102
Genus <i>Spiroptera</i>	103
<i>Spiroptera verrucosa</i>	104

	Page.
Description of nematodes parasitic in the alimentary tract of ruminants—Con.	
Family Angiostomidæ.....	104
Genus <i>Strongyloides</i>	104
Key to species of <i>Strongyloides</i>	105
<i>Strongyloides papillosus</i>	105
<i>Strongyloides ovocinctus</i>	108
Family Trichinellidæ.....	110
Key to subfamilies of Trichinellidæ.....	110
Subfamily Trichurinæ.....	111
Key to genera of Trichurinæ.....	111
Genus <i>Trichuris</i>	111
Key to species of <i>Trichuris</i>	111
<i>Trichuris ovis</i>	112
<i>Trichuris discolor</i>	114
<i>Trichuris alcocki</i>	115
<i>Trichuris globulosa</i>	115
<i>Trichuris cameli</i>	116
<i>Trichuris giraffæ</i>	117
Genus <i>Capillaria</i>	117
Key to species of <i>Capillaria</i>	117
<i>Capillaria brevipes</i>	117
<i>Capillaria longipes</i>	119
<i>Capillaria bovis</i>	120
Subfamily Trichinellinæ.....	120
Genus <i>Trichinella</i>	121
<i>Trichinella spiralis</i>	121
Compendium of species arranged according to hosts.....	121
Addendum.....	124
Index.....	125

ILLUSTRATIONS.

TEXT FIGURES.

	Page.
Fig. 1. <i>Monodontus trigonocephalus</i> . Male and female.....	29
2. <i>Monodontus trigonocephalus</i> . Anterior end of body, viewed from right side.....	29
3. <i>Monodontus trigonocephalus</i> . Bursa of male, spread out.....	29
4. <i>Monodontus trigonocephalus</i> . Bursa of male, viewed from left side....	30
5. <i>Monodontus trigonocephalus</i> . Posterior end of body of female, viewed from right side.....	30
6. <i>Monodontus phlebotomus</i> . Male and female.....	32
7. <i>Monodontus phlebotomus</i> . Anterior end of body, viewed from left side..	32
8. <i>Monodontus phlebotomus</i> . Bursa of male. Dorsal view.....	33
9. <i>Monodontus phlebotomus</i> . Posterior end of body of female, viewed from right side.....	33
10. <i>Monodontus longecirratus</i> . Bursa of male.....	35
11. <i>Chabertia ovina</i> . Male and female.....	36
12. <i>Chabertia ovina</i> . Anterior end of body, viewed from left side.....	36
13. <i>Chabertia ovina</i> . Bursa of male, viewed from left side.....	36
14. <i>Chabertia ovina</i> . Posterior end of body of female, viewed from right side.	37
15. <i>Eucyathostomum longesubulatum</i> . Posterior end of body of male. Ventral view.....	39
16. <i>Eucyathostomum longesubulatum</i> . Female.....	39
17. <i>Eucyathostomum spinulosum</i> . Bursa of male.....	40
18. <i>Esophagostomum columbianum</i> . Male and female.....	42
19. <i>Esophagostomum columbianum</i> . Anterior end of body. Ventral view..	42
20. <i>Esophagostomum columbianum</i> . Posterior end of body of male, with bursa spread out. Ventral view.....	42
21. <i>Esophagostomum columbianum</i> . Bursa of male, viewed from right side.	42
22. <i>Esophagostomum columbianum</i> . Posterior end of body of female, viewed from right side.....	43
23. <i>Esophagostomum radiatum</i> . Male and female.....	45
24. <i>Esophagostomum radiatum</i> . Anterior end of body. Ventral view....	45
25. <i>Esophagostomum radiatum</i> . Bursa of male, spread out.....	45
26. <i>Esophagostomum radiatum</i> . Bursa of male, viewed from left side.....	45
27. <i>Esophagostomum radiatum</i> . Posterior end of body of female, viewed from right side.....	46
28. <i>Esophagostomum venulosum</i> . Male and female.....	48
29. <i>Esophagostomum venulosum</i> . Anterior end of body. Ventral view...	48
30. <i>Esophagostomum venulosum</i> . Bursa of male, spread out.....	48
31. <i>Esophagostomum venulosum</i> . Bursa of male, viewed from right side..	48
32. <i>Esophagostomum venulosum</i> . Posterior end of body of female, viewed from right side.....	48
33. <i>Hæmonchus contortus</i> . Male and female.....	51
34. <i>Hæmonchus contortus</i> . Anterior end of body.....	51
35. <i>Hæmonchus contortus</i> . Posterior end of body of male. Dorsal view...	51
36. <i>Hæmonchus contortus</i> . Body of female in region of vulva, viewed from left side.....	52
37. <i>Hæmonchus contortus</i> . Posterior end of body of female, viewed from left side.....	52

	Page.
FIG. 38. <i>Ostertagia ostertagi</i> . Male and female.....	57
39. <i>Ostertagia ostertagi</i> . Posterior end of body of male, with bursa spread out.....	57
40. <i>Ostertagia ostertagi</i> . Bursa of male, viewed from right side.....	57
41. <i>Ostertagia ostertagi</i> . Spicule of male. Lateral view.....	57
42. <i>Ostertagia ostertagi</i> . Body of female in region of vulva, viewed from right side.....	58
43. <i>Ostertagia ostertagi</i> . Posterior end of body of female, viewed from right side.....	58
44. <i>Ostertagia circumcincta</i> . Male and female.....	60
45. <i>Ostertagia circumcincta</i> . Bursa of male, spread out. Ventral view....	60
46. <i>Ostertagia circumcincta</i> . Bursa of male, viewed from right side.....	61
47. <i>Ostertagia circumcincta</i> . Spicules and gubernaculum of male. Ventral view.....	61
48. <i>Ostertagia circumcincta</i> . Posterior end of body of female, viewed from left side.....	61
49. <i>Ostertagia circumcincta</i> . Tip of tail of female.....	61
50. <i>Ostertagia trifurcata</i> . Male.....	63
51. <i>Ostertagia trifurcata</i> . Posterior end of body of male, with bursa spread out. Ventral view.....	63
52. <i>Ostertagia trifurcata</i> . Posterior end of body of male, viewed from left side.....	63
53. <i>Ostertagia trifurcata</i> . Spicules and gubernaculum. Ventral view....	63
54. <i>Ostertagia trifurcata</i> . Spicule and gubernaculum. Lateral view.....	63
55. <i>Ostertagia marshalli</i> . Male and female.....	64
56. <i>Ostertagia marshalli</i> . Bursa of male, spread out.....	65
57. <i>Ostertagia marshalli</i> . Spicules of male.....	66
58. <i>Ostertagia marshalli</i> . Posterior end of body of female, viewed from left side.....	66
59. <i>Ostertagia occidentalis</i> . Male.....	67
60. <i>Ostertagia occidentalis</i> . Posterior end of body of male, with bursa spread out.....	68
61. <i>Ostertagia occidentalis</i> . Spicules and gubernaculum of male. Ventral view.....	69
62. <i>Ostertagia mentulata</i> . Posterior end of body of male, with bursa partially spread out. Ventral view.....	70
63. <i>Ostertagia mentulata</i> . Spicules and gubernaculum of male. Ventral view.....	70
64. <i>Cooperia curticei</i> . Male and female.....	71
65. <i>Cooperia curticei</i> . Anterior end of body. Lateral view.....	71
66. <i>Cooperia curticei</i> . Posterior end of body of male, with bursa spread out. Ventral view.....	72
67. <i>Cooperia curticei</i> . Bursa of male, viewed from right side.....	72
68. <i>Cooperia curticei</i> . Spicules of male. Ventral view.....	72
69. <i>Cooperia curticei</i> . Spicule of male. Lateral view.....	72
70. <i>Cooperia curticei</i> . Body of female in region of vulva, viewed from right side.....	73
71. <i>Cooperia curticei</i> . Posterior end of body of female, viewed from right side.....	73
72. <i>Cooperia punctata</i> . Male and female.....	75
73. <i>Cooperia punctata</i> . Bursa of male, viewed from right side.....	75
74. <i>Cooperia punctata</i> . Spicules of male. Ventral view.....	75
75. <i>Cooperia punctata</i> . Spicule of male. Lateral view.....	75
76. <i>Cooperia punctata</i> . Body of female in region of vulva, viewed from right side.....	75
77. <i>Cooperia punctata</i> . Posterior end of body of female, viewed from right side.....	75

	Page.
Fig. 78. <i>Cooperia oncophora</i> . Male and female.....	76
79. <i>Cooperia oncophora</i> . Posterior end of body of male, with bursa spread out. Ventral view.....	76
80. <i>Cooperia oncophora</i> . Bursa of male, viewed from right side.....	78
81. <i>Cooperia oncophora</i> . Spicule of male. Lateral view.....	78
82. <i>Cooperia oncophora</i> . Posterior end of body of female, viewed from right side.....	78
83. <i>Cooperia pectinata</i> . Male and female.....	80
84. <i>Cooperia pectinata</i> . Spicules of male. Ventral view.....	80
85. <i>Cooperia pectinata</i> . Body of female in region of vulva, viewed from right side.....	80
86. <i>Cooperia pectinata</i> . Posterior end of body of female, viewed from right side.....	81
87. <i>Nematodirus filicollis</i> . Male and female.....	83
88. <i>Nematodirus filicollis</i> . Anterior end of body.....	83
89. <i>Nematodirus filicollis</i> . Posterior end of body of male. Ventral view..	83
90. <i>Nematodirus filicollis</i> . Posterior end of body of male, viewed from right side.....	83
91. <i>Nematodirus filicollis</i> . Body of female in region of vulva, viewed from right side.....	84
92. <i>Nematodirus filicollis</i> . Posterior end of body of female, viewed from right side.....	84
93. <i>Nematodirus digitatus</i> . Posterior end of body of male.....	85
94. <i>Trichostrongylus instabilis</i> . Male and female.....	89
95. <i>Trichostrongylus instabilis</i> . Posterior end of body of male viewed from left side.....	89
96. <i>Trichostrongylus instabilis</i> . Spicules and gubernaculum of male. Ventral and lateral views.....	89
97. <i>Trichostrongylus instabilis</i> . Posterior end of body of female, viewed from right side.....	89
98. <i>Trichostrongylus probolurus</i> . Male and female.....	91
99. <i>Trichostrongylus probolurus</i> . Posterior end of body of male, viewed from left side.....	91
100. <i>Trichostrongylus probolurus</i> . Spicules and gubernaculum of male. Ventral and lateral views.....	91
101. <i>Trichostrongylus probolurus</i> . Posterior end of body of female, viewed from right side.....	91
102. <i>Trichostrongylus vitrinus</i> . Male and female.....	93
103. <i>Trichostrongylus vitrinus</i> . Posterior end of body of male, viewed from left side.....	93
104. <i>Trichostrongylus vitrinus</i> . Spicules and gubernaculum of male. Ventral and lateral views.....	93
105. <i>Trichostrongylus vitrinus</i> . Posterior end of body of female, viewed from right side.....	93
106. <i>Trichostrongylus extenuatus</i> . Male and female.....	95
107. <i>Trichostrongylus extenuatus</i> . Bursa of male spread out. Dorsal view.....	95
108. <i>Trichostrongylus extenuatus</i> . Bursa of male, viewed from right side...	95
109. <i>Trichostrongylus extenuatus</i> . Spicules and gubernaculum of male. Ventral view.....	95
110. <i>Trichostrongylus extenuatus</i> . Spicules and gubernaculum of male, viewed from right side.....	95
111. <i>Trichostrongylus extenuatus</i> . Posterior end of body of female, viewed from left side.....	96
112. <i>Trichostrongylus capricola</i> . Male and female.....	97

	Page.
Fig. 113. <i>Trichostrongylus capricola</i> . Bursa of male spread out.....	97
114. <i>Trichostrongylus capricola</i> . Bursa of male, viewed from right side...	97
115. <i>Trichostrongylus capricola</i> . Spicules and gubernaculum of male. Ventral view.....	98
116. <i>Trichostrongylus capricola</i> . Spicule and gubernaculum of male. Lateral view.....	98
117. <i>Trichostrongylus capricola</i> . Posterior end of body of female, viewed from left side.....	98
118. <i>Strongylus ventricosus</i> . Posterior end of body of male, showing bursa spread out and spicules.....	99
119. <i>Gongylonema scutatum</i> . Anterior end of body. Dorsal view.....	101
120. <i>Gongylonema scutatum</i> . Posterior end of body of female, viewed from right side.....	101
121. <i>Gongylonema scutatum</i> . Posterior end of body of male. Ventral view.	101
122. <i>Gongylonema scutatum</i> . Posterior end of body of male, viewed obliquely from left side.....	101
123. <i>Gongylonema verrucosum</i> . Anterior end of body. Dorsal view.....	102
124. <i>Gongylonema verrucosum</i> . Posterior end of body of male, viewed obliquely.....	102
125. <i>Gongylonema verrucosum</i> . Posterior end of body of female, viewed from left side.....	102
126. <i>Spiroptera verrucosa</i> . Head. Anterior view.....	103
127. <i>Spiroptera verrucosa</i> . Head. Median view.....	103
128. <i>Spiroptera verrucosa</i> . Head. Lateral view.....	103
129. <i>Spiroptera verrucosa</i> . Posterior end of body of male. Ventral view..	103
130. <i>Strongyloides papillosus</i> . Parasitic adult.....	106
131. <i>Strongyloides papillosus</i> . Portion of body of parasitic adult in region of vulva, viewed from right side.....	106
132. <i>Strongyloides papillosus</i> . Posterior end of body of parasitic adult, viewed from right side.....	106
133. <i>Strongyloides papillosus</i> . Female of free living generation, viewed from left side.....	106
134. <i>Strongyloides ovcinctus</i> . Parasitic adult.....	109
135. <i>Strongyloides ovcinctus</i> . Portion of body of parasitic adult in region of vulva, viewed from left side.....	109
136. <i>Strongyloides ovcinctus</i> . Posterior end of body of parasitic adult, viewed from left side.....	109
137. <i>Strongyloides ovcinctus</i> . Egg-string.....	112
138. <i>Trichuris ovis</i> . Male and female.....	113
139. <i>Trichuris ovis</i> . Posterior end of body of male.....	113
140. <i>Trichuris ovis</i> . Egg.....	113
141. <i>Trichuris discolor</i> . Posterior end of body of male.....	114
142. <i>Trichuris discolor</i> . Egg.....	114
143. <i>Trichuris alcocki</i> . Posterior end of body of male. Lateral view...	115
144. <i>Trichuris globulosa</i> . Posterior end of body of male.....	116
145. <i>Trichuris globulosa</i> . Posterior end view of body of male. Lateral view.....	116
146. <i>Trichuris globulosa</i> . Egg.....	116
147. <i>Capillaria brevipes</i> . Male and female.....	118
148. <i>Capillaria brevipes</i> . Posterior end of body of male. Lateral view...	118
149. <i>Capillaria brevipes</i> . Egg.....	118
150. <i>Capillaria longipes</i> . Male and female.....	119
151. <i>Capillaria longipes</i> . Posterior end of body of male. Lateral view...	120
152. <i>Capillaria longipes</i> . Egg.....	120

THE NEMATODES PARASITIC IN THE ALIMENTARY TRACT OF CATTLE, SHEEP, AND OTHER RUMINANTS.

INTRODUCTION.

Parasites belonging to the group known to zoologists as Nematoda^a are so common in the alimentary tract of cattle, sheep, and other ruminants, and in many instances are so injurious, that the proper identification of the various species is a matter of considerable importance. Obviously, one of the first steps in the study of parasitic diseases is to determine the particular parasites concerned—to be able to recognize the different species and to distinguish them from one another.

In the present paper an attempt has been made to describe the various species of nematodes occurring in the alimentary tract of ruminants in sufficient detail so that any nematodes belonging to known species which may be found in that location can be identified by comparing the specimens with the descriptions herein. For complete references to the literature cited the reader may consult Bureau of Animal Industry Bulletin 39, Index-Catalogue of Medical and Veterinary Zoology.

LIST OF NEMATODES OCCURRING IN THE ALIMENTARY TRACT OF RUMINANTS.^b

The following list contains about 50 species of nematodes which have been reported as parasitic in the alimentary tract of ruminants, and not less than 30 of these are known to occur in this country. The portion of the alimentary canal in which each species is most commonly located (so far as it has been possible to determine) is mentioned, and if a species has been reported as a parasite of domestic cattle, sheep, or goats the fact is stated.

Family Ascaridæ:

Genus *Ascaris*—

Ascaris vitulorum.—Small intestine; cattle.

* *Ascaris ovis*.—Small intestine; sheep.

^aAll parasitic worms with unjointed elongated cylindrical bodies, with a more or less firm cuticle composed of chitin, and with a terminal mouth at one end of the body and an anal opening terminal or subterminal at the other end, belong in the order Nematoda.

^b*Gaigeria pachyscelis* should be added to this list. See Addendum, p. 124.

* The asterisk (*) denotes that specimens of the species indicated (collected in the United States) were examined by the author.

Family Strongylidæ:

Subfamily Strongylinæ—

Genus *Agriostomum*—

Agriostomum vryburgi.—Small intestine; cattle (*Bos indicus*).

^a Genus *Monodontus*—

* *Monodontus trigonocephalus*.—Small intestine; sheep, goat.

* *Monodontus phlebotomus*.—Small intestine; cattle.

Monodontus longecirratus.—Intestine.

Genus *Chabertia*—

* *Chabertia ovina*.—Large intestine; sheep, goat.

Genus *Eucyathostomum*—

Eucyathostomum longesubulatum.—Large intestine.

Eucyathostomum spinulosum.—Intestine.

Genus *Esophagostomum*—

* *Esophagostomum columbianum*.—Large intestine; sheep, goat, ?cattle.

* *Esophagostomum radiatum*.—Large intestine; cattle.

* *Esophagostomum venulosum*.—Large intestine; goat, sheep.

^a Subfamily Metastrongylinæ—Genus *Hæmonchus*—

* *Hæmonchus contortus*.—Fourth stomach; cattle, sheep, goat.

Hæmonchus longistipes.—Fourth stomach.

(? *Hæmonchus*) *bispinosus*.—Stomach.

Genus *Ostertagia*—

* *Ostertagia ostertagi*.—Fourth stomach; cattle.

* *Ostertagia circumcincta*.—Fourth stomach; sheep, goat.

* *Ostertagia trifurcata*.—Fourth stomach; sheep, goat.

* *Ostertagia marshalli*.—Fourth stomach; sheep.

* *Ostertagia occidentalis*.—Fourth stomach; sheep.

* *Ostertagia mentulata*.—Fourth stomach.

Ostertagia brigantiaca.—Small intestine.

Genus *Cooperia*—

* *Cooperia curticei*.—Small intestine; sheep, goat.

* *Cooperia punctata*.—Small intestine; cattle.

* *Cooperia oncophora*.—Small intestine; cattle, sheep, goat.

* *Cooperia pectinata*.—Fourth stomach; cattle.

Genus *Nematodirus*—

* *Nematodirus filicollis*.—Small intestine; cattle, sheep, goat.

Nematodirus spathiger.—Small intestine.

Nematodirus digitatus.—Stomach; cattle (*Bos indicus*).

Genus *Trichostrongylus*—

* *Trichostrongylus instabilis*.—Small intestine; sheep, goat.

Trichostrongylus colubriformis.—Small intestine; sheep.

* *Trichostrongylus probolurus*.—Small intestine; sheep.

* *Trichostrongylus vitrinus*.—Small intestine; sheep, goat.

* *Trichostrongylus extenuatus*.—Fourth stomach; cattle, sheep, goat.

* *Trichostrongylus capricola*.—Small intestine or fourth stomach; sheep, goat.

Species of uncertain generic position—

Strongylus ventricosus.—Small intestine.

Strongylus fordii.—Stomach or intestine; cattle.

Family Filariidæ:

Genus *Gongylonema*—

* *Gongylonema scutatum*.—Mucous lining of esophagus; cattle, sheep, goat.

Gongylonema verrucosum.—Stomach; sheep, cattle (*Bos indicus*).

Genus *Spiroptera*—

Spiroptera verrucosa.—Stomach.

Family Angiostomidæ:

Genus *Strongyloides*—

**Strongyloides papillosus*.—Small intestine; sheep, goat.

**Strongyloides ovocinctus*.—Small intestine.

Family Trichinellidæ:

Subfamily Trichurinæ—

Genus *Trichuris*—

**Trichuris ovis*.—Large intestine; cattle, sheep, goat.

Trichuris discolor.—?Stomach; cattle (*Bos indicus*).

Trichuris alcocki.—(?Large) intestine.

Trichuris globulosa.—?Large intestine.

Trichuris cameli.—Large intestine.

Trichuris giraffæ.—Small intestine.

Genus *Capillaria*—

**Capillaria brevipes*.—Small intestine; sheep.

**Capillaria longipes*.—Small intestine; sheep.

Capillaria bovis.—Small intestine; cattle.

Subfamily Trichinellinæ—

Genus *Trichinella*—

Trichinella spiralis.—Small intestine; accidental in ruminants.

METHODS OF COLLECTING AND PREPARING SPECIMENS.

Though some species of nematodes infesting ruminants may be recognized at a glance with a fair degree of certainty, for example such forms as *Hæmonchus contortus* and *Chabertia ovina*, other species require careful microscopical examination for their identification, either because of their small size or because in their grosser characters several species may look so much alike that they can only be distinguished from each other by means of the finer details of their structure. For the purpose of identification freshly collected specimens may be examined alive in physiological salt solution (about 6 grams of salt to a liter of water) on a glass slide under the microscope, but when time is lacking and if it is desired to retain specimens for future reference it is necessary that they be preserved for later examination.

Owing to the tedious nature of the task of picking out specimens one by one from the viscera of animals examined for parasites and the difficulty of finding nematodes, even those of considerable size, amid the ingesta of the alimentary tract, a more rapid and certain method of collection is desirable. A very satisfactory method consists in taking the various portions of the alimentary canal, opening them with an enterotome or other scissors of convenient size, and evacuating their contents into tall jars of water, washing and scraping their mucous lining in order to detach any adherent parasites. The contents of the jars are stirred up and then allowed to settle for a few minutes, during which time the worms, if any be present, settle toward the bottom together with the heavier ingesta. Then the contents of the jars except a few inches at the bottom are carefully decanted off, more water is added, and the same procedure

repeated. This operation is continued until the liquid no longer becomes turbid when the contents of the jars are stirred. The water is poured off as before and physiological salt solution added. In this solution the worms may remain for several hours without being damaged. Poured out into a shallow dish the worms thus treated are readily seen and may be picked out with comparative ease from the ingesta.

The most satisfactory method of preservation for general purposes is that recommended by Looss (1901a).^a The worms are killed in hot, nearly boiling, 70 per cent alcohol, to which may be added, if desired, 5 per cent of glycerin, or 10 per cent if the worms are small and readily permeated by the killing fluid. To prepare them for study the specimens may then be placed in a mixture of 20 parts of absolute alcohol and 80 parts of carbohc acid, which renders them sufficiently transparent for examination in temporary mounts under the microscope. As an alternative the specimens, if not already in glycerinated alcohol, may be placed in 5 to 10 per cent glycerin in alcohol and left uncovered in a warm, dry place, free from dust, until the alcohol has evaporated, after which more glycerin may be added, if necessary, to cover the specimens. This gradual change by evaporation from alcohol to glycerin prevents the ruinous shrinkage which would result by more abrupt changes from a medium of one specific gravity to one of another, and which commonly results when the usual technical methods are followed. The specimens may then be mounted in glycerin or in glycerin jelly for microscopical examination. As Looss (1901a) has pointed out, glycerin jelly or glycerin is, as a rule, a better mounting medium for nematodes than balsam, which renders specimens so transparent that many details of structure are not visible, or only difficultly so.

STRUCTURE OF NEMATODES PARASITIC IN THE ALIMENTARY TRACT OF RUMINANTS.

In the following brief review of the anatomy of nematodes parasitic in the alimentary tract of ruminants those details of structure which are of practical importance in determining species are discussed in a general way.

FORM.

As indicated by their name, the nematodes are more or less thread-like in form. They are elongated, cylindrical, usually attenuated toward one or both extremities. In the genus *Trichuris* the anterior portion of the body is much more slender than the posterior portion, and from their fancied resemblance to a whip the worms of that genus are commonly known as whip-worms.

^a The references are to the Index-Catalogue of Medical and Veterinary Zoology, published as Bulletin 39, Bureau of Animal Industry, Department of Agriculture.

SIZE.

In size the adult nematodes infesting the alimentary tract of ruminants range from a length of about 3 mm. and a thickness of 50μ or less in the smallest species to a length of 25 cm. and a thickness of 5 mm. or more in the largest species. The majority of the species are forms less than 20 mm. in length and $\frac{1}{2}$ mm. in thickness. *Ascaris vitulorum* (p. 25) is the largest species, while *Trichostrongylus extenuatus* (p. 94) and the two species of *Strongyloides* (p. 104) share the distinction of being the smallest. The females of each species, as is commonly the case with nematodes, are usually larger than the males, both in length and in thickness.

CUTICLE.

The chitinous cuticle which forms the covering of the body varies in thickness, as a rule, according to the size of the worms. The layer of hypodermis which underlies the cuticle is thickened in the dorsal and ventral median lines, and in the lateral lines. These lines are especially conspicuous in the genus *Ascaris*. The excretory vessels are located in the lateral lines. These vessels unite near the head and open on the ventral surface of the body through an unpaired excretory pore (*e. p.*, fig. 2). Besides the median and lateral longitudinal lines the cuticle may be marked with other longitudinal lines, very narrow, in some instances (genus *Cooperia*) resembling rows of little dots. In the genus *Trichuris* the cuticle on the ventral surface is modified to form the so-called bacillary band, consisting of a mass of small rod-like structures perpendicular to the surface and projecting as little points. In the genus *Capillaria* similar bands may also be present in the lateral and dorsal lines. The cuticle in many cases is transversely striated. In the genus *Gongylonema* the cuticle in the anterior portion of the body bears numerous small shields or tubercles (fig. 119). The cuticle on the head and in the cervical region may be inflated in certain species, giving that portion of the body a swollen appearance (*c. i.*, figs. 24, 29). Narrow cuticular membranes or wings may be present attached along the longitudinal lines, sometimes extending the entire length of the body (*l. m.*, fig. 19). In *Gongylonema verrucosum* such a membrane is also present in the dorsal line. Cervical papillæ (*c. p.*, figs. 19, 34), are commonly present in the neck region, one in each lateral line. A transverse cervical groove on the ventral surface in the neighborhood of the excretory pore is a rather prominent feature of the genera *Chabertia* and *Æsophagostomum* (*c. g.*, figs. 12, 19).

Shedding of the cuticle, preceded by the formation of a new cuticle inside the old, is a characteristic of the growth and development of nematodes from the embryonic to the adult stage. One of the species

considered in the present paper (*Strongyloides ovocinctus*, p. 108), apparently undergoes successive molts in the adult stage, the cast-off skins serving as egg cases.

DIGESTIVE SYSTEM.

The digestive system is simple, consisting of a terminal mouth at the anterior end of the body, an esophagus, and a tubular straight intestine terminating in an anus which is either terminal at the posterior end of the body, or subterminal, on the ventral surface of the body near the posterior end.

MOUTH.

The mouth is very small in some species and relatively very large in others. The species with small mouths have small heads (figs. 34, 65) and those with large mouths, large heads (figs. 2, 12). In the family Ascaridæ the mouth is supplied with three large lips. The head may be provided with circum-oral papillæ; in the family Strongylidæ these are usually, if not always, 6 in number, 2 lateral and 4 submedian; they are frequently inconspicuous in species with small heads. The cuticle surrounding the mouth, as for example in *Æsophagostomum*, may be inflated, forming an annular mouth collar (*m. c.*, fig. 19). The genus *Chabertia* is characterized by a double crown of small, pointed chitinous denticles bordering the mouth (fig. 12). In *Æsophagostomum* and *Eucyathostomum* the mouth is provided with one or two crowns of slender leaf-like processes attached to its chitinous frame work and projecting radially inward and forward. In the genus *Hæmonchus* the small mouth is supplied with a tiny lancet. Some of the large-mouthed forms have teeth inside the buccal capsule (figs. 2, 7), and in one species, *Agriostomum vryburgi*, the anterior border of the mouth bears 8 strong recurved teeth projecting inward.

ESOPHAGUS.

In the Trichinellidæ the esophagus is very long, consisting of a cord of cells placed end to end in a single row pierced through the center by a continuous lumen. In the other families the adults all possess a muscular esophagus (*es.*, fig. 2), usually claviform, gradually enlarged posteriorly. The free-living generation of the genus *Strongyloides* is characterized by an esophagus with a posterior bulb (*b.*, fig. 133) which contains a masticatory apparatus in its interior. This is a common characteristic of the first larval stage of the Strongylidæ, but none of the adult nematodes parasitic in the alimentary tract of ruminants so far as known possesses an esophagus of this type.

INTESTINE.

The intestine is of little importance from the standpoint of classification. In the male it unites at its posterior end with the vas deferens to form a cloaca whose opening serves the double purpose of a genital pore and anus.

ANUS.

The anus of the female is usually removed some distance from the posterior end of the body (*an.*, fig. 5). The length and shape of the postanal region, which may be termed the tail, are important characters in distinguishing the females of closely related species from one another. In the family Trichinellidæ the anus is practically terminal in both sexes. The anus of the males of the family Strongylidæ is terminal or almost terminal. In the Ascaridæ and Filariidæ the males are supplied with papillæ in the neighborhood of the anus, some preanal, some postanal, which are of importance in classification (fig. 129).

NERVOUS SYSTEM.

A nerve ring (*n. r.*, fig. 2) whose location varies somewhat in different species surrounds the esophagus usually near its middle.

REPRODUCTIVE SYSTEM.

The sexes are always separate except possibly in the parasitic generation of the genus *Strongyloides*. In this genus there is a free-living sexual generation consisting of males and females, but the parasitic generation consists only of egg-producing individuals somewhat different in structure from the females of the free-living generation. Though these individuals may be interpreted as hermaphroditic forms, they are more likely true parthenogenetic females, whose eggs develop without fertilization.

The genital glands and ducts of nematodes are tubular, very long and much coiled and twisted, loosely attached in the body cavity and comprising most of the bulk of the viscera.

MALE REPRODUCTIVE SYSTEM.

The males are usually smaller than the females and in the Strongylidæ may be readily distinguished from the latter by the presence of a copulatory bursa at the posterior end of the body, a membranous structure supported by rays or ribs, and serving as a clasping organ. The testicle, seminal vesicle, and vas deferens form a single continuous tubular thread-like structure, very tenuous and frequently much coiled and twisted in its proximal portion, and thicker and straighter

in its distal portion, joining the intestine to form a cloaca which opens to the exterior through the anus.

The intromittent organs, or spicules, and the bursa present characters of great importance from the standpoint of classification.

SPICULES.

The males of all the species of nematodes known to occur in the alimentary tract of ruminants with the exception of *Trichinella spiralis*, which is without spicules, possess spicules located in the posterior portion of the body. The spicules are composed of chitin, and by means of muscles with which they are supplied may be exerted through the anal opening. The Trichurinae have but one spicule (*sp.*, figs. 139, 148) which is surrounded by a prepuce-like sheath (*sh.*, figs. 139, 148) that is evaginated when the spicule is exerted. This sheath in the genus *Trichuris* is armed with numerous spines. In the genus *Capillaria* it is unarmed in species occurring in ruminants. Two spicules are present in all the species parasitic in the alimentary canal of ruminants belonging to families other than the Trichinellidae. In the Filariidae one of the spicules is short and thick, the other long and filiform (fig. 129). The spicules in the Ascaridae and Strongylidae are equal or subequal in length. In the latter family, to which the bulk of the species of nematodes parasitic in ruminants belong, the spicules in several genera are relatively long and filiform (*sp.*, figs. 8, 90), in others short and more or less complicated and irregular in shape, but always elongated (*sp.*, figs. 39, 79). The long filiform spicules are usually alate; that is, supplied with one or two narrow longitudinal membranous lamellæ.

In the genus *Nematodirus* the two spicules are united, at least in their distal portion, by a membrane (*sp.*, fig. 89). Many species have in addition to the spicules a third chitinous piece, smaller than the spicules, situated just dorsal of them, usually not exsertile, and known as an accessory piece, or gubernaculum (*gub.*, figs. 115, 116). Spicules of the short type in certain species are divided distally into two or three processes; in some instances these processes form a pincer-like apparatus (fig. 63)

BURSA.

A more or less well-developed bursa (figs. 4, 25) is present in the males of all species of Strongylidae. A small bursa-like structure is present in the genus *Capillaria* (*b. m.*, figs. 148, 151), supported on each side by a short leg-like process. In the Filariidae there are lateral membranes along the sides of the posterior end of the body of the male supported by several pairs of stalked papillæ (fig. 124). The Ascaridae have papillæ on the tail of the male, but no lateral membranes. In both these families the anus is some distance from the

tip of the tail. The males of the genus *Trichuris* (fig. 139) are without a bursa, and the anus is terminal.

The bursa in the Strongylidæ consists of three lobes, two lateral and one dorsal, supported by five systems of rays, a right and left ventral system, a right and left lateral system, and a dorsal system. The dorsal lobe may be shorter or longer than, or equal in length to, the lateral lobes. In the genus *Hæmonchus* it is not median in position but attached asymmetrically to one of the lateral lobes (fig. 35). A small accessory bursal membrane attached to the posterior end of the body ventral of the dorsal lobe is present in the genus *Ostertagia* (a. b., figs. 45, 56). The dorsal lobe in the genus *Nematodirus* (figs. 89, 90) is very short and divided into two small lobules, located one on either side of the median line.

Each ventral system of rays^a consists of two rays, designated as ventro-ventral (*v. v.*, fig. 25) and latero-ventral (*l. v.*, fig. 25). Each lateral system is divided into three rays, designated as externo-lateral (*e. l.*, fig. 25), medio-lateral (*m. l.*, fig. 25), and postero-lateral (*p. l.*, fig. 25). The ventral and lateral rays support the lateral lobes of the bursa. Each lateral lobe contains also a ray belonging to the dorsal system, known as the externo-dorsal ray (*e. d.*, fig. 25).

The dorsal system in addition to the paired externo-dorsal ray consists of a median dorsal ray (*d.*, fig. 25) which supports the dorsal lobe. This ray may extend nearly the entire length of the dorsal lobe unbranched (fig. 10), terminating in a digitate tip, or may divide into two main branches, each of which may give off subbranches on its inner or outer side (*t. d.*, fig. 45) or terminate in a digitate tip (*t. d.*, fig. 66). The externo-dorsal ray, already mentioned, in some species comes off from the stem of the dorsal ray (*e. d.*, fig. 25), in others originates at its base (*e. d.*, fig. 113). In *Nematodirus* the unpaired median ray is lacking, but is represented by two dorsal rays (*d.*, figs. 89, 90), each supporting one of the lobules of the dorsal lobe. In *Hæmonchus* the dorsal ray is entirely displaced to one side of the median line (*d.*, fig. 35). In *Monodontus trigonocephalus* and *M. phlebotomus* (figs. 3, 8) the dorsal ray (*d.*) extends backward on one side of the median line, dividing distally into three branches, one corresponding to the externo-dorsal ray (*e. d. l.*) and two (*t. d.*) corresponding to the usually symmetrical main branches of the dorsal ray. The other externo-dorsal ray (*e. d. r.*) in these two species takes its origin at or near the root of the dorsal ray.

The tips of the ventral, lateral, and externo-dorsal rays form small papillæ on the outer or inner surface of the bursa, those of the externo-dorsal and externo-lateral rays on the outer surface, the others on the inner surface.

^a Different authors have applied different names to the various rays supporting the bursa. In the present paper the plan proposed by Looss (1905o) is followed.

A pair of prebursal papillæ (*p. b. p.*, fig. 20) projecting from the lateral lines of the body and situated just in front of the base of the bursa is commonly present in the Strongylidæ.

The bursa is of special importance in the identification of species, because as a rule the details of its structure may be readily made out. In some species the bursa may be easily spread out flat; in others it is very difficult to prepare specimens, especially preserved specimens, so that the bursal characters can be determined. In many instances, however, when the bursa can not be spread out easily, a side view may be obtained from which sufficient may be seen to make possible the identification of the species.

FEMALE REPRODUCTIVE SYSTEM.

The females may be distinguished from the males of the same species by their usually somewhat larger size, by the presence of eggs, and the possession of a vulva on the ventral surface of the body somewhere between the mouth and the anus, its position varying in different species. As in the male, the reproductive glands and ducts form tubular thread-like structures. In all of the nematodes occurring in the alimentary tract of ruminants, except the Trichinellidæ, there are two ovaries and two uteri. The uteri unite to form a single vagina, which opens through the vulva.

VULVA.

Different species, genera, and families differ with respect to the location and shape of the vulva. In the Trichinellidæ (*, figs. 138, 147, 150) it is situated just back of the posterior end of the esophagus at the juncture of the slender anterior portion of the body and the thicker posterior portion. The vulva in the Strongylidæ (*, figs. 1, 11, 33) is usually behind the middle of the body, in some genera close to the anus. Its shape varies, but it is commonly elongated, usually transversely, sometimes longitudinally, and occasionally it is elongated in a diagonal direction. It is sometimes situated on a protuberance (*vul.*, fig. 27). Its lips may be salient, often vesicular. In some cases the vulva is covered by a more or less conspicuous backward projecting process (*lab.*, figs. 36, 42), which may be small and thin, or large, thick, and very prominent, as in *Hæmonchus*.

VAGINA.

In the Trichinellidæ the exact point at which the uterus ends and the vagina begins is not readily determined, but in the other families the vagina is readily identified as that portion of the genital system extending from the juncture of the two uteri to the vulva. In many cases it is very short and practically nil (*vag.*, fig. 22), but in some species in which the males have long spicules it is correspondingly developed to a considerable length (*vag.*, fig. 32).

UTERUS AND OVARY.

As already noted, in all forms parasitic in the alimentary tract of ruminants except the Trichinellidæ, there are two uteri and two ovaries. The terminal portions of the uteri in the Strongylidæ are modified at their juncture to form structures known as ovijectors (*ovij.*, fig. 42). Commonly three portions may be recognized in each ovijector, first, a cylindrical muscular portion fused end to end with the corresponding portion of the other ovijector (*ovij.* 1); second, a short bulbous sphincter-like muscular portion (*ovij.* 2), and third, a narrower cylindrical nonmuscular portion (*ovij.* 3) which joins the end of the uterus proper (*ut.*).

The ovaries are usually very long, narrower than the uteri, much coiled and twisted, and portions of them may be wound spirally about the intestine (*ov.*, fig. 132).

EGGS.

The eggs (*e.*, figs. 27, 136) of all the nematodes parasitic in the alimentary tract of ruminants are oval or ellipsoidal in shape, and except in the Trichurinæ the shells are imperforate. In this subfamily (figs. 140, 149) there is a perforation at each pole of the egg closed by a plug-like operculum, and outside the chitinous shell there is a thin albuminous layer, smooth or with little projections. This outer albuminous layer is more conspicuous in the Ascaridæ; the thick-shelled eggs with an outer albuminous layer whose surface is roughened by numerous mammillate projections are very characteristic of the genus *Ascaris*.

In the Filariidæ, Strongylidæ, and Angiostomidæ the eggs usually have very thin shells, their size (length) ranging from 40μ in *Strongyloides* to 260μ in *Nematodirus*. Most species have eggs whose diameter is less than 100μ . In *Gongylonema* the egg may contain a vermiform embryo when deposited, but in most genera the eggs when laid are in earlier stages of segmentation. The eggs of *Strongyloides* by the time they reach the outside world in the feces of the host frequently contain vermiform embryos, but the eggs of most species pass out of the body of the host before the embryos have developed beyond the so-called morula stage. An unusual condition relative to the eggs is met with in *Strongyloides ovocinctus*. Here the eggs after deposition, instead of occurring isolated among the intestinal contents of the host, are arranged in strings (fig. 137). Each string seems to be composed of the cast-off cuticle of an adult worm, packed with eggs. The adult worm apparently undergoes successive molts and the eggs (*e.*, fig. 136) as they pass out of the vulva lodge beneath the loosened outer cuticle, in which they remain when the worm abandons it.

DESCRIPTION OF NEMATODES PARASITIC IN THE ALIMENTARY TRACT OF RUMINANTS.

According to the system of classification followed in the present paper, any species of nematode known to occur in the alimentary tract of ruminants may be placed in one of five families. The family to which any given specimen belongs may be determined by comparison with the following key:

KEY TO FAMILIES OF NEMATODA.

1. Body at its middle more than 2 mm. in thickness *Ascaridæ*, p. 24
 Body at its middle less than 2 mm. in thickness 2
2. Males lacking; parthenogenetic females with few eggs in uterus (not over 25); small slender forms not over 6 mm. long *Angiostomidæ*, p. 104
 Dioecious, both males and females being distinguishable; females usually with numerous eggs in uterus 3
3. Male with a single spicule, or without spicules; female with a single uterus and ovary; eggs, in oviparous species, with an opening at each pole closed by a plug-like operculum *Trichinellidæ*, p. 110
 Male with two spicules; female with double uterus and two ovaries; eggs without polar openings in the shell 4
4. Male with unequal spicules, one short, and one much longer.... *Filariidæ*, p. 99
 Male with equal or subequal spicules..... *Strongylidæ*, p. 26

FAMILY ASCARIDÆ COBBOLD, 1864.

FAMILY DIAGNOSIS.—Nematoda: Mouth usually surrounded with three lips which are often supplied with papillæ. One lip median, dorsal, the other two submedian, ventral, touching one another in the ventral median line. Males provided with two spicules. Females with a double ovary, oviparous. Development, so far as known, direct, without intermediate host.

TYPE GENUS.—*Ascaris* Linnæus, 1758.

KEY TO GENERA OF ASCARIDÆ.

- One genus in ruminants *Ascaris*, p. 24

Genus ASCARIS Linnæus, 1758.

1758: *Ascaris* Linnæus, 1758a, pp. 644, 648.

1780: *Stomachida* Pereboom, 1780a, pp. 1-24.

1800: *Fusaria* Zeder, 1800a, pp. 6, 16-68.

1821: *Lombricoides* Mérat, 1821a, p. 225.

GENERIC DIAGNOSIS.—*Ascaridæ* (p. 24): Mouth with three well-developed lips, which generally have denticulated borders. Male with two equal spicules, and with numerous papillæ on the ventral surface of the body in front of and behind the anus. Vulva of female near or in front of the middle of the body. Shell of egg thick, with surface of outer albuminous layer raised in numerous mammillate projections.

TYPE SPECIES.—*Ascaris lumbricoides* Linnæus, 1758.

Two species of *Ascaris* are recognized as parasites of ruminants. These may be distinguished by the following key:

KEY TO SPECIES OF ASCARIS.

Parasitic in sheep; male 7 to 15 cm. long, female 8 to 15 cm. long. . . *Ascaris ovis*, p. 25
 Parasitic in cattle; male 15 to 25 cm. long, female 22 to 30 cm. long.

Ascaris vitulorum, p. 25

***Ascaris ovis* Rudolphi, 1819.**

1819: *Ascaris ovis* Rudolphi, 1819a, p. 54 (from intestine, *Ovis domestica* [= *O. aries*]).

SPECIFIC DIAGNOSIS.—*Ascaris* (p. 24): Male 7 to 15 cm. long by 2 mm. in maximum thickness. Ventral surface of tail with two rows of 45 to 50 papillæ each. Three pairs of these papillæ are postanal, and there is one unpaired papilla near the extremity of the tail.

Female 8 to 15 cm. long, thicker than the male. Vulva toward the anterior third of the body.

Host.—*Sheep (*Ovis aries*).

Location.—Small intestine.

LOCALITIES COLLECTED.—Europe, United States.

This species is of rather rare occurrence. It has been seen a number of times in Europe. Curtice (1890c, p. 151) reports the finding of an *Ascaris* in sheep, which he identifies as *Ascaris lumbricoides*. The Bureau of Animal Industry collection contains specimens of *Ascaris* collected from sheep at Blairsville, Pa., at Brookings, S. Dak., and at Bethesda, Md.

It is considered questionable by some authors whether *Ascaris ovis* represents a distinct species, or whether it is simply *Ascaris lumbricoides* (man) or *Ascaris suum* (pig) in an unusual host.

***Ascaris vitulorum* Goeze, 1782.**

1782: *Ascaris vitulorum* Goeze, 1782a, p. 72 (from *Bos taurus*, Europe).

1790: *Ascaris vituli* Gmelin, 1790a, p. 3032 (in part).

SPECIFIC DIAGNOSIS.—*Ascaris* (p. 24): Lips without papillæ, narrowed anteriorly. Tail terminated by a mucronate conical tip. Esophagus followed by a rudimentary ventricle.

Male 15 to 25 cm. long by 3 mm. in maximum thickness. Ventral surface of tail supplied with two irregular rows of 10 to 15 papillæ each, all preanal.

Female 22 to 30 cm. long by 5 mm. in thickness. Vulva toward the anterior sixth of the body. Eggs 75 to 80 μ in length.

Hosts.—*Cattle (*Bos taurus*); zebu (*Bos indicus*).

Location.—Small intestine, occasionally fourth stomach.

LOCALITIES COLLECTED.—Europe, Japan, Ceylon, West Indies.

This parasite seems to be more common in calves than in adults. The Bureau of Animal Industry collection contains specimens collected in Antigua and in Cuba. Schneider (1866a, p. 36) reports an *Ascaris* from a cow which may possibly belong to the species *A. vitulorum*. Schneider, however, identifies it as *Ascaris megalcephala* (= *A. equorum*), a species of common occurrence in the horse. Neumann (1892a, p. 404) states that ascarids in cattle may cause local inflammation of the intestinal mucosa, and colic, and exceptionally may cause a rupture of the intestine when present in large numbers.

FAMILY STRONGYLIDÆ COBBOLD, 1864.

FAMILY DIAGNOSIS.—Nematoda: Head with six more or less distinct circumoral papillæ. Buccal capsule present or absent, may be armed with teeth in its interior. Esophagus without posterior bulb. Males with two equal or subequal spicules, and with a more or less well developed caudal bursa, each lateral lobe of which is usually supplied with six supporting rays. Females with two ovaries; vulva may be in front of the middle of the body, but is usually behind the middle. Oviparous. Development, so far as known, direct, without intermediate host.

TYPE GENUS.—*Strongylus* Mueller, 1780.

Two subfamilies may be distinguished in this family.

KEY TO SUBFAMILIES OF STRONGYLIDÆ.

- Mouth cavity enlarged to form a buccal capsule; diameter of head over 75 μ .
Strongylinæ, p. 26
 Mouth cavity very small, not enlarged to form a buccal capsule; diameter of head less than 75 μ Metastrongylinæ, p. 47

Subfamily STRONGYLINÆ Railliet, 1893.

SUBFAMILY DIAGNOSIS.—Strongylidæ (p. 26): Mouth cavity enlarged to form a buccal capsule which may or may not be provided with teeth in its interior.

TYPE GENUS.—*Strongylus* Mueller, 1780.

Five^a genera belonging to the subfamily Strongylinæ are represented among the nematodes parasitic in the alimentary tract of ruminants.

KEY TO GENERA OF STRONGYLINÆ.

1. Buccal capsule armed with strong, recurved chitinous teeth at its entrance.
Agriostomum, p. 27
 Buccal capsule without teeth at its entrance, may be supplied with teeth or lancets at its base 2
2. Buccal capsule small (less than three-fourths the diameter of the head); its chitinous framework supplied on its inner surface with one or two crowns of delicate chitinous leaf-like processes which project forward and inward; cuticle surrounding the mouth usually inflated to form an annular mouth collar, sharply limited behind by a deep constriction 4
 Buccal capsule large (more than three-fourths the diameter of the head); mouth opening not surrounded by a vesicular mouth collar 3
3. Buccal capsule very large, without teeth or lancets in its interior; border of mouth armed with a double crown of numerous small triangular processes or denticles *Chabertia*, p. 35
 Buccal capsule supplied at its base with a strong dorsal tooth projecting forward into its cavity, and with 2 or 4 ventral teeth or lancets.... *Monodontus*, p. 27
4. Buccal capsule longer than broad; medio-lateral and postero-lateral rays of male bursa divergent *Encyathostomum*, p. 38
 Buccal capsule broader than long; medio-lateral and postero-lateral rays of male bursa close together, parallel *Æsophagostomum*, p. 40

^a Including *Gaigeria* there are six genera. See Addendum, p. 124.

Genus AGRIOSTOMUM Railliet, 1902.

1902: *Agriostomum* Railliet, 1902b, pp. 107-108, 110.

GENERIC DIAGNOSIS.—Strongylinæ (p. 26): Buccal capsule rather deep, communicating with the esophagus by a wide opening at its base. Buccal capsule without teeth or lancets at its base, but surrounded at its entrance by a chitinous ring armed with strong, recurved, hook-like teeth. Cephalic extremity bent dorsally, supplied anteriorly with a projecting cuticular plate, which apparently forms the boundary of the mouth.

TYPE SPECIES.—*Agriostomum vryburgi* Railliet, 1902.

KEY TO SPECIES OF AGRIOSTOMUM.

One species *Agriostomum vryburgi*, p. 27

Agriostomum vryburgi Railliet, 1902.

1902: *Agriostomum vryburgi* Railliet, 1902b, pp. 107-108 (from duodenum, *Bibos indicus* [= *Bos indicus*], Sumatra).

SPECIFIC DIAGNOSIS.—*Agriostomum* (p. 27): Body cylindroidal, whitish in color, slightly attenuated at the ends. Striation of the cuticle very delicate, scarcely perceptible. Two delicate cervical papillæ at the level of the nerve ring, each consisting of a short, bluntly pointed process upon a cylindrical stalk. Cephalic extremity slightly inflated at the level of the buccal capsule. Buccal capsule ovoid, with chitinous ring at its anterior border armed with 8 strong recurved, hook-like teeth, symmetrically placed on each side; the two first (ventral) very close together, the two last (dorsal) with points facing one another, and with a rather large interval between their bases. The third on each side is apparently the most developed, the fourth or dorsal the least developed. Although the cuticle is not inflated in the cervical region to form a vesicular swelling, yet at some distance behind the buccal capsule there is present a ventral groove similar to that found in the *œsophagostomes*.

Male 9.2 mm. long, 300 μ thick. Bursa short, rather narrow, lobed. Spicules equal, slightly swollen at their base, alate and transversely striated, 840 μ long.

Female 14.5 to 15.5 mm. long, 450 μ thick near the middle. Tail very short, thick, blunt; anus 150 μ from its tip, upon a slight protuberance; vulva 470 μ from its tip, upon a more prominent protuberance. Eggs ellipsoidal or subcylindrical, 170 to 195 μ long by 60 to 92 μ wide, in process of segmentation when deposited.

Host.—Zebu (*Bos indicus*).

LOCATION.—Duodenum.

LOCALITY COLLECTED.—Sumatra.

This species has been collected by Dr. Vrijburg, veterinarian at Deli, Sumatra, and described by Railliet (1902b) from whom the above description and the diagnosis of the genus of which it is the type are taken.

Genus MONODONTUS^a Molin, 1861.

1861: *Monodontus* Molin, 1861a, pp. 435, 463-470.

1902: *Bunostomum* Railliet, 1902b, pp. 108-109, 110 (type species, *Bunostomum trigonocephalum* [Rudolphi, 1808]).

GENERIC DIAGNOSIS.—Strongylinæ (p. 26): Cuticle transversely striated. Buccal capsule supplied at its base with a strong dorsal tooth projecting forward into its cavity, and with two or four ventral lancets; and supplied ventrally at its entrance

^a See Addendum, p. 124.

with two highly refractile chitinous pieces, continuing as two thin plates with rounded edges, almost contiguous at their inner border, and joining along their outer border with two dorsal plates, likewise thin with rounded edges, in such a manner that the outline of these structures forms a sinuous and continuous line. Six circum-oral papillæ; two lateral, each with a slender prolongation upon the dorsal plates, and four submedian, the dorsal submedian papillæ shorter than the ventral. Cephalic extremity curved dorsally. Cervical papillæ short and obtuse.

TYPE SPECIES.—*Monodontus semicircularis* Molin, 1861.

Three species of *Monodontus* are recognized among the nematodes of ruminants. With regard to one of these, *Monodontus longecirratus*, it is questionable whether it properly belongs in this genus in view of the fact that the dorsal ray in this species is unbranched, whereas in *Monodontus semicircularis* (the type of the genus), as described and figured by Molin (1861a), the dorsal ray divides into two prominent branches. Until, however, more is known relative to the details of structure in the type-species of *Monodontus* and in *M. longecirratus* it is considered advisable to retain the latter in the genus *Monodontus*.

Railliet has proposed the name *Bunostomum* to replace *Monodontus* on account of the existence of very similar early generic names, *Monodon* Linnæus, *Monodonta* Lamarek, and *Monodontes* Montf. Under the International Code of Zoological Nomenclature *Monodontus* Molin is not invalidated by any of these three names in spite of their great similarity in spelling. *Bunostomum* may be recognized if it can be shown that *Monodontus semicircularis* and *M. trigonocephalus* are sufficiently different to warrant placing them in separate genera, but at present our knowledge of the former species is too incomplete to justify the separation.

KEY TO SPECIES OF MONODONTUS.

1. Dorsal ray of bursa of male median with tridigitate tip; externo-dorsal ray originates at the base of the dorsal ray; male 18 mm. long, female 23 mm. long.

Monodontus longecirratus, p. 34

Dorsal ray of bursa asymmetrically situated on the left-hand side of the median line; right externo-dorsal ray originates from the stem of the dorsal ray at or near its base; distally the dorsal ray divides into 3 branches, namely, the right externo-dorsal ray, and two terminal branches with tridigitate tips. 2

2. Dorsal buccal tooth long; length of its dorsal border greater than the distance from its tip to the opening of the mouth; 2 ventral buccal teeth; spicules of male 600 to 640 μ long; male 12 to 17 mm. long, female 19 to 26 mm. long.

Monodontus trigonocephalus, p. 28

Dorsal buccal tooth short; length of its dorsal border less than the distance from its tip to the opening of the mouth; 2 ventral buccal teeth, and 2 subventral buccal teeth or lancets; spicules of male 3.5 to 4 mm. long; male 10 to 12 mm. long, female 16 to 19 mm. long. *Monodontus phlebotomus*, p. 31

***Monodontus trigonocephalus* ^a (Rudolphi, 1808) Railliet, 1900.**

(Figs. 1-5.)

1808: *Strongylus trigonocephalus* Rudolphi, 1808a, pl. 2, figs. 5-6; 1809a, pp. 231-232 (based on specimens said to have been collected from the stomach of a dog).^b

^a See Addendum, p. 124.

^b Apparently the specimens were improperly labelled, as Railliet has pointed out, or perhaps the dog from which the specimens were collected had just eaten the intestines of an infested sheep.

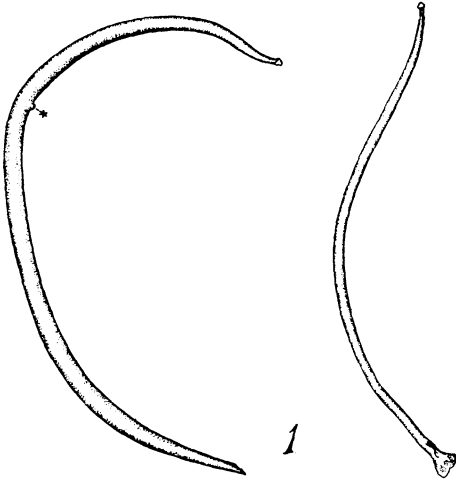
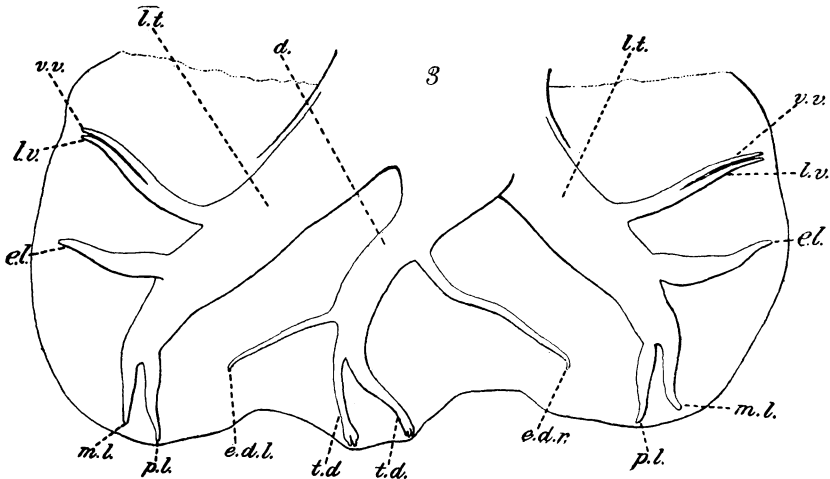
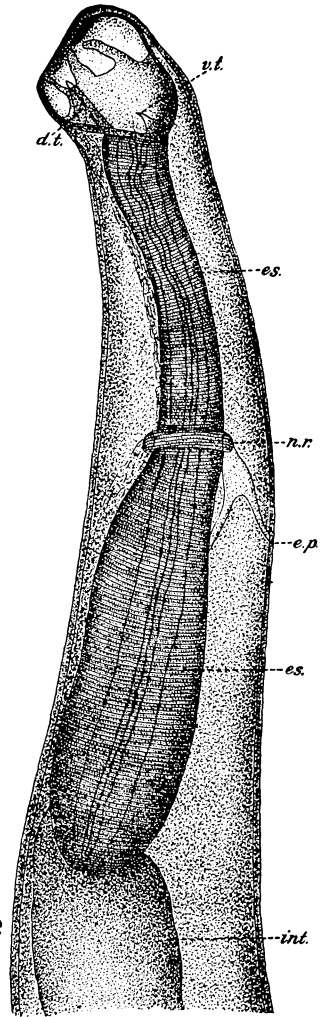


FIG. 1.—*Monodontus trionocephalus*. Male at right, female at left. * Vulva. $\times 5$. (Original.)

FIG. 2.—*Monodontus trionocephalus*. Anterior end of body viewed from right side. *d. t.*, dorsal buccal tooth; *e. p.*, excretory pore; *es.*, esophagus; *int.*, intestine; *n. r.*, nerve ring; *v. t.*, ventral buccal tooth. $\times 75$. (Original.)

FIG. 3.—*Monodontus trionocephalus*. Bursa of male spread out. Dorsal view. *d.*, dorsal ray; *e. d. l.*, left externo-dorsal ray; *e. d. r.*, right externo-dorsal ray; *e. l.*, externo-lateral ray; *l. t.*, trunk of rays of lateral lobe; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *t. d.*, terminal branch of dorsal ray; *v. v.*, ventro-ventral ray. $\times 75$. (Original.)



- 1829: *Strongylus cernuus* Creplin, 1829b, pp. 9-10 (from *Ovis aries*).
 1845: *Sclerostoma hypostomum* (Rudolphi) Dujardin, 1845a, pp. 255-257 (in part).
 1851: *Dochmius hypostomus* (Rudolphi) Diesing, 1851a, p. 301 (in part).
 1861: *Monodontus wedlii* Molin, 1861a, pp. 467-469.
 1868: *Dochmius cernuus* (Creplin) Baillet, 1868a, pp. 547-557.
 1885: *Uncinaria cernua* (Creplin) Railliet, 1885a, p. 362, fig. 254.
 1900: *Strongylus* (*Monodontus*) *cernuus* (Creplin) Railliet, 1900d, p. 86.
 1900: *Uncinaria* (*Monodontus*) *cernua* (Creplin) Railliet, 1900d, p. 87.
 1900: *Monodontus trigonocephalus* (Rudolphi) Railliet, 1900d, p. 87.
 1902: *Bunostomum trigonocephalum* (Rudolphi) Railliet, 1902b, p. 108.

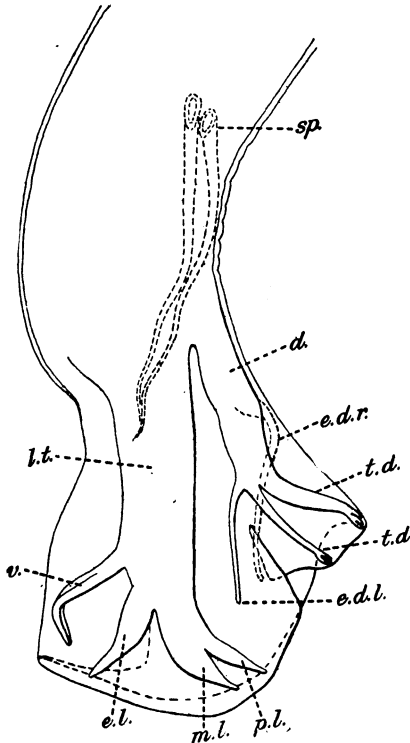


FIG. 4.—*Monodontus trigonocephalus*. Bursa of male viewed from left side. *d.*, dorsal ray; *e. d. l.*, left externo-dorsal ray; *e. d. r.*, right externo-dorsal ray; *e. l.*, externo-lateral ray; *l. t.*, trunk of rays of lateral lobe; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *sp.*, spicules; *t. d.*, terminal branch of dorsal ray; *v.*, ventral rays. $\times 75$. (Original.)

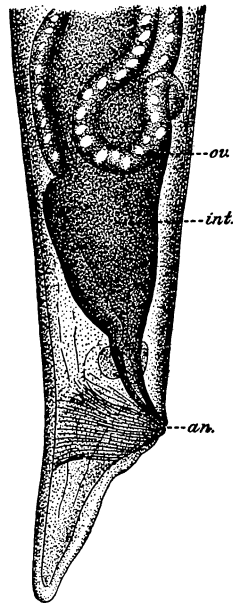


FIG. 5.—*Monodontus trigonocephalus*. Posterior end of body of female viewed from right side. *an.*, anus; *int.*, intestine; *ov.*, ovary. $\times 75$. (Original.)

SPECIFIC DIAGNOSIS.—*Monodontus* (p. 27): Diameter of head (dorso-ventral) 150 to 200 μ . Dorsal buccal tooth long (*d. t.*, fig. 2); length of its dorsal border greater than the distance from its tip to the opening of the mouth. Two short ventral buccal teeth or lancets (*v. t.*, fig. 2); distance from the base of the buccal capsule to the tips of these teeth much less than the distance to the tip of the dorsal tooth. Esophagus (*es.*, fig. 2) 0.8 to 1.25 mm. in length. Cervical papillæ slightly in front of the middle of the esophagus.

Male 12 to 17 mm. long, slightly less than 0.5 mm. in thickness. Bursa (figs. 3, 4) funnel shaped; dorsal median lobe somewhat shorter than the lateral lobes. Ventral and lateral rays come off from a large common trunk (*l. t.*, figs. 3, 4), that of the left side

larger than that of the right. The two ventral rays (*v. v.*, *l. v.*, fig. 3; *v.*, fig. 4) are long and slender, separated by a narrow cleft except in their proximal portion where they are united, taking origin from the ventral side of the common trunk at a point more than half way from its root to the origin of the externo-lateral ray. The externo-lateral ray (*e. l.*, figs. 3, 4) diverges widely from the other two lateral rays, and is curved ventrally, while the latter are curved dorsally. The postero-lateral (*p. l.*, figs. 3, 4) and medio-lateral rays (*m. l.*, figs. 3, 4) diverge somewhat from one another, and the former is a little longer than the latter, so that its tip lies nearer the border of the bursa. Distance between the tips of the medio-lateral and externo-lateral rays slightly greater than that between the latter and the tips of the ventral rays. Dorsal ray (*d.*, figs. 3, 4) asymmetrically branched. A long slender externo-dorsal ray (*e. d. r.*, figs. 3, 4) comes off from the stem of the dorsal ray near its root, on the right side. The stem of the dorsal ray extends backward on the left-hand side of the median line and a little more than half way between its root and the posterior border of the median dorsal lobe of the bursa, forks into three branches, namely, the left externo-dorsal ray (*e. d. l.*, figs. 3, 4), and two branches (*t. d.*, figs. 3, 4) which terminate at the posterior border of the dorsal median lobe of the bursa, each in three usually unequal digitations. Spicules (*sp.*, fig. 4) 600 to 640 μ long by about 30 μ in diameter near their proximal end, gradually attenuated to a sharp point posteriorly, slightly twisted, alate.

Female 19 to 26 mm. long by 0.5 to 0.75 mm. in maximum thickness. Posterior end of body (fig. 5) gradually attenuated, tail thick, short, with blunt, rounded tip. Anus (*an.*, fig. 5) 250 to 275 μ from tip of tail. Vulva elliptical, transversely elongated, with narrow lips, usually not salient, situated a little more than one-third the length of the body from the anterior end. Vagina short, less than 200 μ in length, may be bent S-like. Combined length of the muscular portions of the two ovijectors at least 450 μ . Eggs ellipsoidal, 75 to 83 μ long by 38 to 45 μ wide, in course of segmentation when deposited.

HOSTS.—*Sheep (*Ovis aries*); *goat (*Capra hircus*); chamois (*Rupicapra rupicapra*).

LOCATION.—Small intestine.

LOCALITIES COLLECTED.—Europe, United States.

Monodontus trigonocephalus is a frequent parasite of sheep in the southern United States and has been found as far north as New York. It is common among sheep in the neighborhood of Washington, D. C. It is a blood sucker, and when numerous is no doubt responsible for considerable injury to its host.

Its life history is presumably similar to that of the hookworm of man; that is, it undergoes a direct development without intermediate host.

***Monodontus phlebotomus* ^a Railliet, 1900.**

(Figs. 6-9.)

1803: *Strongylus radiatus* Rudolphi, 1803a, pp. 13-15 (in part).

1866: *Strongylus radiatus* Rudolphi of Schneider, 1866a, pp. 128, 132, 137, 139, 141, 144.

1868: *Dochmius radiatus* (Rudolphi) Leuckart, 1868a, p. 411.

1885: *Uncinaria radiata* (Rudolphi) Railliet, 1885a, pp. 362-363.

1900: *Monodontus* sp. Railliet, 1900e, p. 106.

1900: *Monodontus phlebotomus* Railliet, 1900b, p. 781.

1902: *Bunostomum phlebotomum* Railliet, 1902b, pp. 108-109 (*Strongylus radiatus* Rudolphi of Schneider, 1866, renamed).

1906: *Bunostomum radiatum* (Schneider) Linstow, 1906, Centralbl. f. Bakteriöl., Parasitenk. [etc.], Jena, 1 Abt., v. 43 (1), 22. Dec., Originale, pp. 91-92, figs. 6, 8.

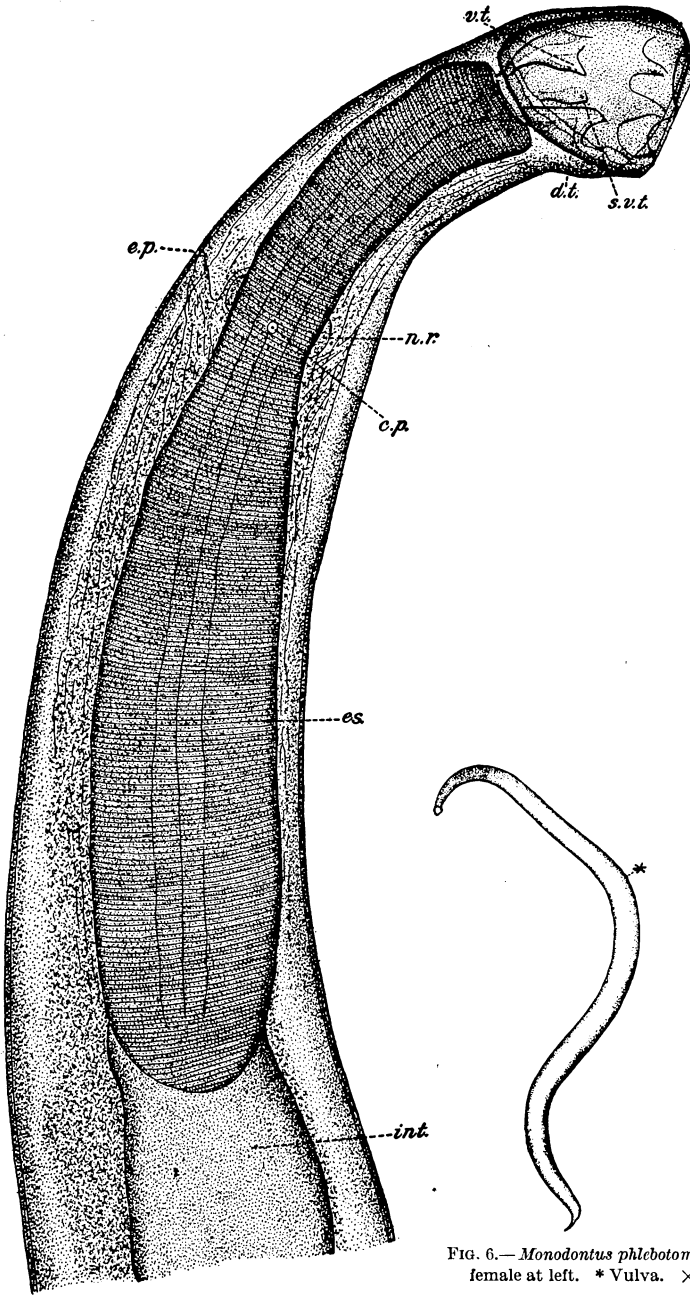


FIG. 7.—*Monodontus phlebotomus*. Anterior end of body viewed from left side. *c. p.*, cervical papilla; *d. t.*, dorsal buccal tooth; *e. p.*, excretory pore; *es.*, esophagus; *int.*, intestine; *n. r.*, nerve ring; *s. v. t.*, subventral buccal tooth; *v. t.*, ventral buccal tooth. $\times 75$. (Original.)

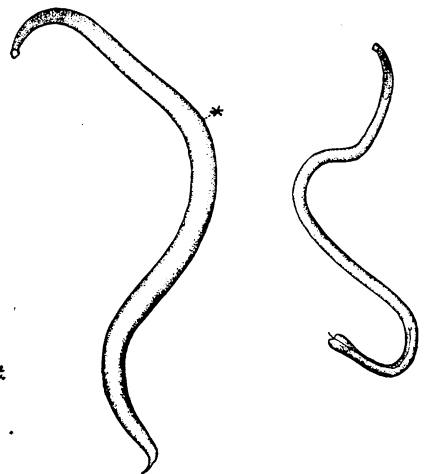


FIG. 6.—*Monodontus phlebotomus*. Male at right, female at left. * Vulva. $\times 5$. (Original.)

SPECIFIC DIAGNOSIS.—*Monodontus* (p. 27): Diameter of head (dorso-ventral) 200 to 250 μ . Dorsal buccal tooth (*d. t.*, fig. 7) short; length of its dorsal border less than the distance from its tip to the opening of the mouth. Two subventral buccal teeth (*s. v. t.*, fig. 7) or lancets in addition to two ventral teeth (*v. t.*, fig. 7). Tips of all the buccal teeth about equally distant from the base of the buccal capsule. Esophagus (*es.*, fig. 7) 1.25 to 1.5 mm. or slightly more in length. Cervical papillæ (*c. p.*, fig. 7) opposite the anterior portion of the middle third or the posterior portion of the anterior third of esophagus.

Male 10 to 12 mm. long, slightly less than 0.5 mm. in thickness. Bursa (fig. 8) funnel shaped; dorsal median lobe somewhat shorter than the lateral lobes. Ventral and

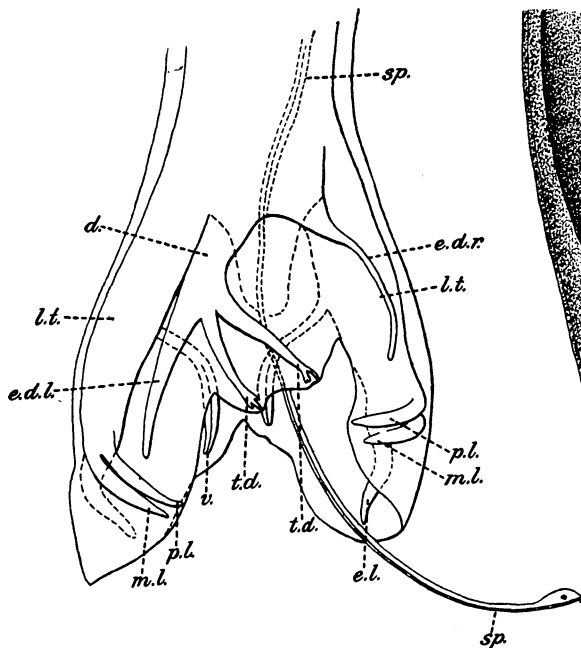


FIG. 8.—*Monodontus phlebotomus*. Bursa of male. Dorsal view. *d.*, dorsal ray; *e. d. l.*, left externo-dorsal ray; *e. d. r.*, right externo-dorsal ray; *e. l.*, externo-lateral ray; *l. t.*, trunk of rays of lateral lobe; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *sp.*, spicules; *t. d.*, terminal branch of dorsal ray; *v.*, ventral rays. $\times 75$. (Original.)

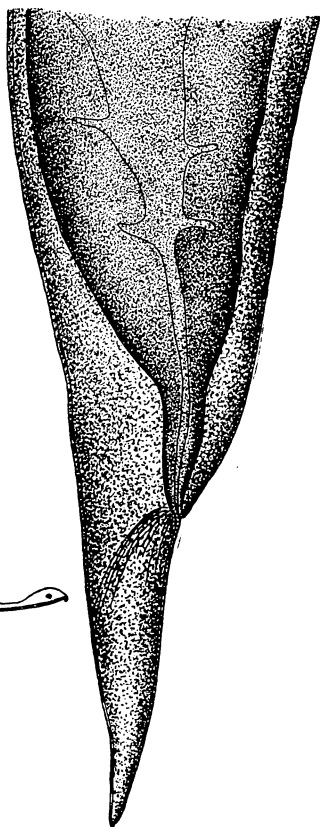


FIG. 9.—*Monodontus phlebotomus*. Posterior end of body of female viewed from right side. $\times 75$. (Original.)

lateral rays come off from a large common trunk (*l. t.*, fig. 8), that of one side of the bursa larger than that of the other. The two ventral rays (*v.*, fig. 8) are long and slender, separated by a narrow cleft except in their proximal portion where they are united, taking origin from the ventral side of the common trunk a little less than half way between its root and the origin of the externo-lateral ray. The externo-lateral ray (*e. l.*, fig. 8) diverges widely from the other two lateral rays which are close together and but slightly divergent distally. The externo-lateral ray curves ventrally, the other two dorsally. The postero-lateral ray (*p. l.*, fig. 8) is slightly longer than the medio-lateral ray (*m. l.*, fig. 8), its tip in consequence being nearer

the border of the bursa. Distance between the tips of the medio-lateral and externo-lateral rays slightly greater than that between the latter and the tips of the ventral rays. Dorsal ray (*d.*, fig. 8) asymmetrically branched. A long slender externo-dorsal ray (*e. d. r.*, fig. 8) comes off at the root of the dorsal ray on its right side. The stem of the dorsal ray extends backward on the left-hand side of the median line and about half way between its root and the posterior edge of the median dorsal lobe of the bursa, forks into three branches, namely, the left externo-dorsal ray (*e. d. l.*, fig. 8), and two branches (*t. d.*, fig. 8) which terminate at the posterior edge of the median dorsal lobe of the bursa each in three usually unequal digitations. Spicules (*sp.*, fig. 8) 3.5 to 4 mm. long, filiform, alate.

Female 16 to 19 mm. in length by a little more than 0.5 mm. in thickness. Posterior end of body (fig. 9) gradually attenuated, then near anus suddenly reduced in size, and terminating in a rather slender bluntly-pointed tail. Anus 400 to 500 μ from the tip of the tail. Vulva elliptical, transversely elongated, with narrow, salient lips, situated a little in front of the middle of the body. Vagina long and sinuous. Combined length of the muscular portions of the two ovijectors at least 1 mm. Eggs ellipsoidal, 75 to 98 μ long by 40 to 50 μ wide, in course of segmentation when deposited.

HOSTS.—*Cattle (*Bos taurus*); zebu (*Bos indicus*).

LOCATION.—Small intestine.

LOCALITIES COLLECTED.—United States, Cuba, Panama, Europe, Sumatra.

Monodontus phlebotomus has been found by Dawson (1906, Bull. 86, Florida Exper. Sta.) associated with and a probable cause of the so-called "salt sickness" of Florida, which is characterized "at first by low fever, diarrhea, loss of appetite, soon becoming chronic, with continuance of low fever, constipation, loss of appetite, progressive emaciation, and pronounced anemia, which in many cases terminates fatally." Treatment with thymol has been recommended for hookworm disease in cattle, but Conradi and Barnett (1908, Bull. 137, South Carolina Exper. Sta.) found that thymol in a dose of 150 grains had no apparent effect upon the parasites in one case in which this remedy was used.

The same authors (1908) have studied the development of the hookworm of cattle from the egg to the final larval stage. This portion of the life history is very similar to that of *Hæmonchus contortus*. Presumably infection of cattle occurs through swallowing the larvæ, or as a result of the entrance of larvæ through the skin in a similar manner to that occurring in the case of the hookworms of man and of the dog.

Monodontus longecirratus¹ (Linstow, 1879) Ransom, 1911.

(Fig. 10.)

1879: *Strongylus longecirratus* Linstow, 1879b, pp. 332-333, pl. 5, fig. 18 (from intestine of *Bos grunniens* L.).

1909: *Bunostomum longecirratum* (Linstow, 1879) Railliet and Henry, 1909b, p. 170.

1911: *Monodontus longecirratus* (Linstow, 1879) Ransom, 1911, pp. 14, 28, 34-35, 121, fig. 10 (the present paper).

SPECIFIC DIAGNOSIS.—*Monodontus* (p. 27): Cuticle with very fine transverse striations. Esophagus very muscular, one-thirteenth of the length of the body. Buccal capsule large, armed with chitinous teeth at its base.

Male 18 mm. long by 0.4 mm. wide. Spicules unusually long and slender, measur-

¹ See Addendum, p. 124.

ing 4.5 mm. in length. Bursa (fig. 10) with 3 lobes. Lateral lobes large. Ventral rays (probably two in each lateral lobe, close together and parallel, though Linstow describes and figures the ventral rays as single) long, slender, with tips terminating some distance from the border of the bursa near the tip of the externo-lateral ray, which is curved in a ventral direction and reaches nearly to the border of the bursa. The medio-lateral and postero-lateral rays curve in a dorsal direction and their tips are much nearer to the tip of the externo-dorsal ray than to the tip of the externo-lateral ray. The externo-dorsal ray is long and slender. The ventral and lateral rays come off from a large common trunk. The externo-dorsal ray originates at the junction of this common trunk with the dorsal ray at the base of the bursa. The dorsal lobe of the bursa is much smaller than the lateral lobes, and is supported by the unpaired dorsal ray which terminates near the posterior border of the dorsal lobe in a tri-digitate tip.

Female 23 mm. long by 1 mm. in thickness, with a slender, rather long, pointed tail.

Host.—Yak (*Bos grunniens*).

Location.—Intestine.

Locality collected.—(?)

Only one occurrence of this species has been recorded. The foregoing diagnosis is based on the description and figure given by Linstow (1879b).

Genus *CHABERTIA* Railliet & Henry, 1909.

1909: *Chabertia* Railliet and Henry, 1909b, p. 169.

GENERIC DIAGNOSIS.—Strongylinae (p. 26): Anterior end of head obliquely truncate so that the mouth faces antero-ventrally. Buccal capsule large, without teeth in its interior. Border of mouth armed with a double crown of numerous small triangular pointed processes. Dorsal median lobe of bursa slightly longer than the lateral lobes. Latero-ventral and ventro-ventral rays close together. Medio-lateral and postero-lateral rays close together. Externo-lateral ray diverges somewhat the medio-lateral ray. Dorsal ray bifurcated toward its posterior end and each bifurcation divided into two terminal branches, the inner of which is the longer. Externo-dorsal rays originate from the dorsal ray between its root and its bifurcation. Prebursal papillae present. Spicules long, tubular, slender. Gubernaculum, or accessory piece, present. Vulva of female a short distance in front of the anus.

TYPE SPECIES.—*Chabertia ovina* (Fabricius, 1788) Railliet and Henry, 1909.

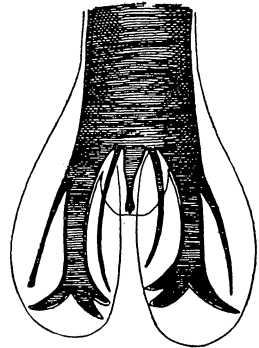


FIG. 10.—*Monodontus longicetratus*. Bursa of male. Enlarged. (After Linstow, 1879b, pl. 5, fig. 18).

KEY TO SPECIES OF CHABERTIA.

One species.....*Chabertia ovina*, p. 35

Chabertia ovina (Fabricius, 1788) Railliet and Henry, 1909.

(Figs. 11-14.)

1788: *Strongylus ovinus* Fabricius, 1788 (on the authority of Railliet, 1893a, p. 463).—Fabricius, 1794a, pp. 5-12, pl. 1, figs. 1a-1c, 2a-2d (from intestine of sheep, Europe).

1802: *Strongylus contortus* Rudolphi, 1802a, pp. 15-17 (in part).

1819: *Strongylus hypostomus* Rudolphi, 1819a, pp. 33, 263 (from cecum, *Antilope rupicapra* [= *Rupicapra rupicapra*], Europe).

1845: *Sclerostoma hypostomum* (Rudolphi) Dujardin, 1845a, pp. 255-257.

1851: *Dochmius hypostomus* (Rudolphi) Diesing, 1851a, p. 301.

1867: *Sclerostomum hypostomum* (Rudolphi) Leuckart, 1867b, p. 19.

1899: *Sclerostomum ovinum* Stossich, 1899d, pp. 102-103.

1909: *Chabertia ovina* (Fabricius) Railliet and Henry, 1909b, p. 169.

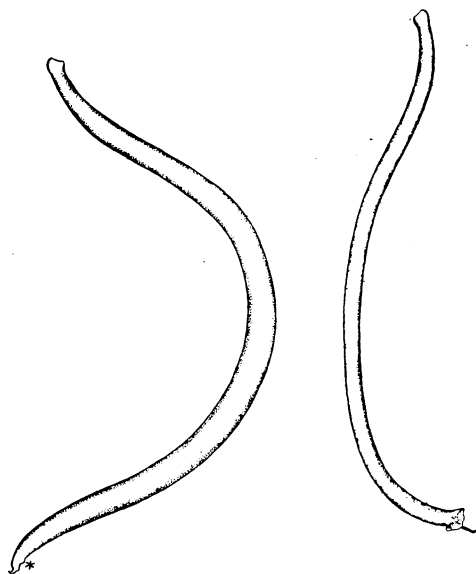


FIG. 11.—*Chabertia ovina*. Male at right, female at left.
* Vulva. $\times 5$. (Original.)

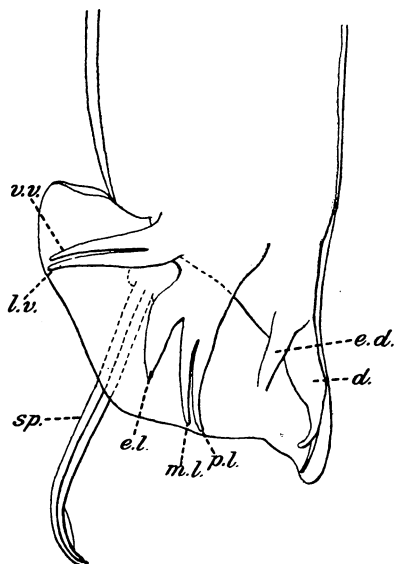


FIG. 13.—*Chabertia ovina*. Bursa of male viewed from left side. *d.*, dorsal ray; *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *sp.*, spicules; *v. v.*, ventro-ventral ray. $\times 75$. (Original.)

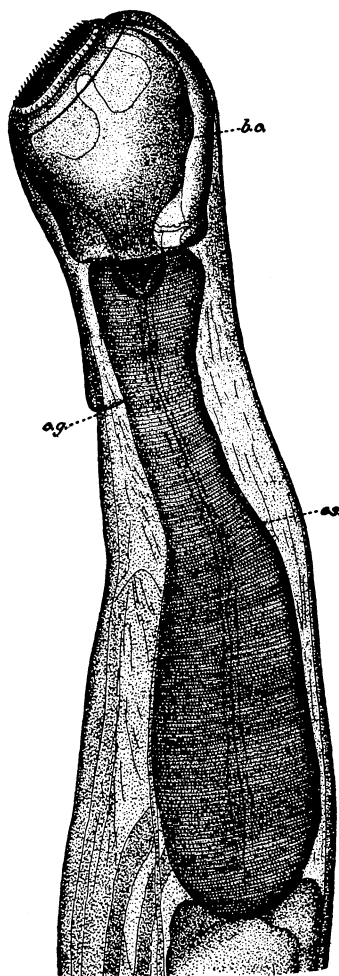


FIG. 12.—*Chabertia ovina*. Anterior end of body viewed from left side. *b. c.*, buccal capsule; *c. g.*, cervical groove; *es.*, esophagus. $\times 75$. (Original.)

SPECIFIC DIAGNOSIS.—*Chabertia* (p. 35): Body cylindroidal, almost uniform in thickness. Diameter of head (fig. 12) slightly greater than that of the cervical region of the body and nearly equal to the maximum diameter of the body. Anterior end of head obliquely truncate, so that the mouth faces antero-ventrally. Border of mouth armed with a double crown of numerous small triangular pointed processes or denticles. Buccal capsule (*b. c.*, fig. 12) very large, without teeth in its interior. On the ventral surface of the body just in front of the excretory pore, which is about one-fourth of the length of the body from its anterior end, is a short transverse cervical groove (*c. g.*, fig. 12). Cuticle on ventral surface in front of this groove very slightly inflated. Esophagus (*es.*, fig. 12) claviform, 1.2 to 1.4 mm. long. Nerve ring about one-third the length of the esophagus from its anterior end. Cervical papillæ not evident.

Male 13 to 14 mm. long by a little over one-third mm. in thickness. Dorsal median lobe of bursa (fig. 13) slightly longer than the lateral lobes. Tips of ventral, medio-lateral, postero-lateral, and dorsal rays reach the border, or nearly to the border of the bursa. Tips of the externo-lateral and externo-dorsal rays fall considerably short of the border, the former slightly nearer the border of the bursa than the latter. Distance between the tips of these two rays slightly less than the distance between the tip of the externo-lateral, and the tip of the latero-ventral ray. Ventro-ventral (*v. v.*, fig. 13) and latero-ventral (*l. v.*, fig. 13) rays close together. Medio-lateral (*m. l.*, fig. 13) and postero-lateral (*p. l.*, fig. 13) rays closely approximated throughout their course. Externo-lateral ray (*e. l.*, fig. 13) diverges somewhat from the medio-lateral ray. Externo-lateral and externo-dorsal rays considerably thicker than the ventral, medio-lateral and postero-lateral rays, which are about equal in thickness. Externo-dorsal rays (*e. d.*, fig. 13) take origin from the stem of the dorsal ray about one-third the distance from its root to its bifurcation. Dorsal ray (*d.*, fig. 13) bifurcated at about three-fifths the distance from its root to the posterior border of the dorsal median lobe of the bursa. Each of the branches of the dorsal ray divided into two—namely, an inner branch, which reaches the edge of the bursa, and an outer branch, which is thicker than the inner branch and about half as long, not reaching the border of the bursa. Prebursal papillæ large. Spicules (*sp.*, fig. 13) 1.3 to 1.7 mm. long, tubular, slender, about 30μ in diameter anteriorly, tapering to an acute point posteriorly, alate. Gubernaculum 80 to 100μ long.

Female 17 to 20 mm. long by a little less than one-half mm. in maximum thickness. Posterior end of body (fig. 14) gradually attenuated from in front of the vulva toward the anus. Behind the anus the body is suddenly reduced in diameter, terminating in a sharply pointed short mucronate tail. The body curves ventrally behind the vulva, and dorsally behind the anus. Anus (*an.*, fig. 14) 200 to 230μ from the tip of the tail. Vulva (*vul.*, fig. 14) transversely elongated, crescentic, 375 to 450μ from the tip of the tail. Vagina (*vag.*, fig. 14) about 150μ long. Combined length of muscular portions of ovijectors (*ovij.*, fig. 14) at least 200μ . Eggs ellipsoidal, 90 to 100μ long by about 50μ wide; in course of segmentation when laid.

HOSTS.—*Cattle (*Bos taurus*); *sheep (*Ovis aries*); *goat (*Capra hircus*); Dorcas gazelle (*Gazella dorcas*); white oryx (*Oryx leucoryx*); chamois (*Rupicapra rupicapra*); roe deer (*Capreolus capreolus*); fallow deer (*Dama dama*); stag (*Cervus elaphus*); argali (*Ovis ammon*).

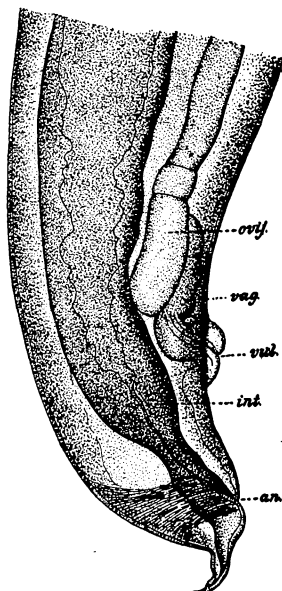


FIG. 14.—*Chabertia ovina*. Posterior end of body of female viewed from right side. *an.*, anus; *int.*, intestine; *ovij.*, ovijector; *vag.*, vagina; *vul.*, vulva. $\times 75$. (Original.)

LOCATION.—Large intestine, rarely other parts of alimentary tract.

LOCALITIES COLLECTED.—Europe, United States, Africa, South America, Asia, Australia.

This species appears to be comparatively harmless. Its food consists of the vegetable material in the contents of the large intestine. The buccal capsule is commonly found filled with such material.

Genus EUCYATHOSTOMUM Molin, 1861.

1861: *Eucyathostomum* Molin, 1861a, pp. 435, 455–463.

GENERIC DIAGNOSIS.—Strongylinæ (p. 26): Buccal capsule large, with wide anterior opening whose border is armed internally with a crown of numerous, slender, acutely pointed processes. Bursa with dorsal lobe projecting posteriorly beyond the lateral lobes. Ventral rays of each lateral lobe close together, united proximally and may present the appearance of an undivided ray. The ventral rays and the three lateral rays of each lateral lobe come off from a common trunk. The externo-dorsal ray is widely separated from the lateral rays, and originates from the dorsal trunk, or from one of the paired dorsal rays near its origin. Two long parallel dorsal rays, giving off two branches externally. The dorsal rays may present the appearance of being fused in the median line to form a single dorsal ray, with a bipartite tip. Three external branches are given off by the dorsal ray, the proximal one of which is the externo-dorsal ray. Spicules long, slender, equal. Vulva of female a short distance in front of the anus.

TYPE SPECIES.—*Eucyathostomum longesubulatum* Molin, 1861.

Two species of *Eucyathostomum* occur in the alimentary tract of ruminants, neither of which has been found in the United States.

KEY TO SPECIES OF EUCYATHOSTOMUM.

Externo-dorsal ray of male bursa originates at the root of the dorsal ray; male, 15 mm. long, female 21 mm. long.....*Eucyathostomum spinulosum*, p. 40

Externo-dorsal ray of male bursa originates from the outer side of the dorsal ray some distance from its root; male 10 to 12 mm. long, female 15 to 20 mm. long.

Eucyathostomum longesubulatum, p. 38

Eucyathostomum longesubulatum Molin, 1861.

(Figs. 15–16.)

1861: *Eucyathostomum longesubulatum* Molin, 1861a, pp. 460–462, pl. 26, figs. 1, 2 (from intestine (cecum) of *Cervus campestris* [= *Blastocercus campestris*] and *Cervus rufus* [= *Mazama rufa*], Brazil).

1899: *Sclerostomum longesubulatum* (Molin) Stossich, 1899d, p. 113.

SPECIFIC DIAGNOSIS.—*Eucyathostomum* (p. 38): Head continuous with body. Mouth cavity cyathiform, cylindrical, with wide opening whose diaphanous circular border is armed externally with four larger spines or papillæ, internally with a crown of smaller processes. Body subcylindrical, straight, attenuated toward both ends. Anterior end truncate with inflated cuticle.

Male 10 to 12 mm. long by 0.3 mm. thick. Tail with wide copulatory bursa, obliquely truncated, prolonged in a triangular dorsal lobe, and supported by three systems of rays. The dorsal system gives off three rays from each side of the main trunk, which terminates in a bipartite tip. Each lateral trunk gives off four rays, the anterior of which is bifid. Spicules two, very long, filiform, acutely pointed.

Female 15 to 20 mm. long by 0.3 to 0.5 mm. thick. Tail long, subulate, scarcely curved. Anus remote from tip of tail. Vulva in posterior part of body near anus; its superior lip greatly inflated, rather protuberant. Uterus bicornate.

HOSTS.—Pampas deer (*Blastocercus campestris*); red brocket (*Mazama rufa*).

LOCATION.—Cecum.

LOCALITY COLLECTED.—Brazil.

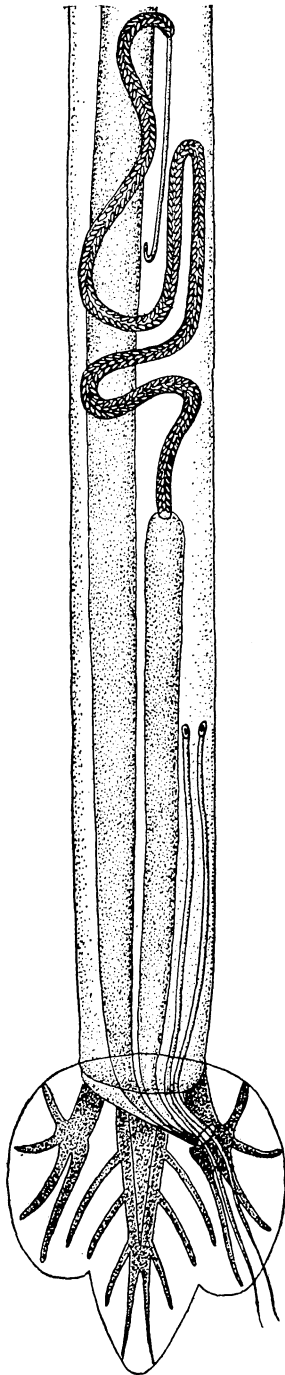


FIG. 15.—*Eucyathostomum longesubulatum*. Posterior end of body of male. Ventral view. Enlarged. (After Molin, 1861a, pl. 26, fig. 1.)

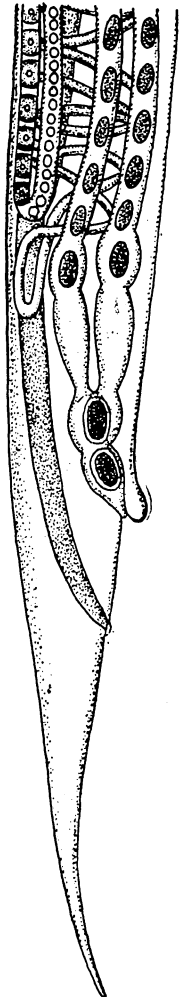
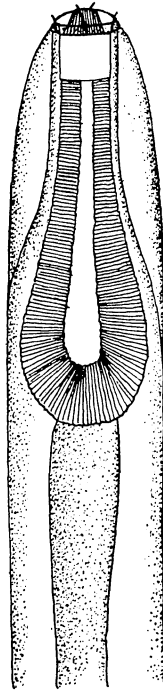


FIG. 16.—*Eucyathostomum longesubulatum*. Female. Anterior end of body at left. posterior end at right. Enlarged. (After Molin, 1861a, pl. 26, fig. 2.)

The foregoing diagnosis is based on the description and figures given by Molin (1861a). There are no later records of the occurrence of this species.

Eucyathostomum spinulosum (Linstow, 1879) Railliet and Henry, 1909.

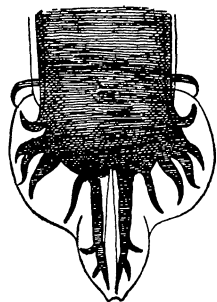
(Fig. 17.)

1879: *Strongylus* (?=*Eucyathostomum*) *spinulosus* Linstow, 1879b, pp. 331-332, pl. 5, fig. 17 (from intestine of *Capra ibex* L.)

1899: *Sclerostomum spinulosum* (Linstow) Stossich, 1899d, pp. 111-112.

1909: *Eucyathostomum spinulosum* (Linstow) Railliet and Henry, 1909b, p. 170.

SPECIFIC DIAGNOSIS.—*Eucyathostomum* (p. 38): Male 15 mm., female 21 mm. long. Thickness about 1 mm. in both sexes. Body spindle-shaped. Mouth opening provided with setæ on the border similar to *Eucyathostomum longesubulatum*. Buccal capsule large. Head without the larger spines described by Molin as present on the head of *E. longesubulatum*. Bursa five-lobed. The anterior lobes supported each by a single ray (?=prebursal papilla—B. H. R.). The lateral lobes have five rays, the four anterior of which originate close together. The unpaired posterior lobe (=dorsal lobe—B. H. R.) is supported by two parallel rays, each of which gives off two branches on its outer side.



Host.—Alpine ibex (*Capra ibex*).

Location.—Intestine.

Locality collected.—Europe.

Nothing is known concerning the species beyond the description given by Linstow (1879b), from which the foregoing diagnosis has been taken.

Genus *ÆSOPHAGOSTOMUM* Molin, 1861.

FIG. 17.—*Eucyathostomum spinulosum*. Bursa of male. Enlarged. (After Linstow, 1879b, pl. 5, fig. 17.)

1861: *Æsophagostomum* Molin, 1861a, pp. 435, 443-450.

GENERIC DIAGNOSIS.—Strongylinæ (p. 26): Adults 8 to 25 mm. in length, with head 75 μ or more in diameter. Buccal capsule small. Attached to the chitinous framework of the buccal capsule inside the buccal cavity there are usually one or two crowns of delicate chitinous leaf-like processes. Cuticle surrounding the mouth usually inflated to form a ring-like mouth collar, which is sharply limited behind by a deep annular constriction. Six circum-oral papillæ—two lateral, two subdorsal, and two subventral—penetrating the mouth collar. Lateral papillæ short and thick, others longer and more slender. Excretory pore in front of the middle of the esophagus. At or in front of the excretory pore a transverse groove and a corresponding fold in the cuticle which extend round the body toward the dorsal surface. The cuticle between the mouth collar and the transverse groove usually inflated to form a vesicular swelling. Lateral membranous wings may be present beginning at the transverse groove and extending backward along the lateral lines. Cervical papillæ present. Bursa of male with two lateral lobes united by a smaller median lobe. In each lateral lobe six rays, namely, two ventral rays, three lateral rays, and one externo-dorsal ray. Ventral rays of equal size, parallel, close together. Medio-lateral and postero-lateral rays parallel, close together. Dorsal ray (in median lobe) with two main branches, each of which is also divided into two unequal or subequal branches. Spicules more than 0.5 mm. long, slender, tubular, pointed; gubernaculum present, but not conspicuous. Prebursal papillæ present. Vulva, naked, a short distance in front of the anus. Eggs oval, with thin shells. Larval stages, in some cases at least, occur in nodules in the intestinal wall of the host. Adults free in the lumen of the intestine, usually the large intestine.

TYPE SPECIES.—*Æsophagostomum subulatum* Molin, 1861=*Æ. dentatum* (Rudolphi, 1803) Molin, 1861.

Three species of *Æsophagostomum* are known to occur in the alimentary tract of ruminants, and all three have been found in this country.

KEY TO SPECIES OF *ÆSOPHAGOSTOMUM*.

1. Cervical papillæ near the middle of the esophagus; lateral membranes broad; spicules of male less than 1 mm. long; vulva about 1 mm. from the tip of the tail..... 2
 Cervical papillæ post-esophageal; lateral membranes very narrow; spicules of male 1.1 to 1.5 mm. long; vulva about 0.5 mm. from the tip of the tail; male 11 to 16 mm. long, female 13 to 24 mm. long..... *Æsophagostomum venulosum*, p. 46
2. Mouth collar almost hemispherical; its height a little less than half its diameter; externo-lateral ray of bursa separated from the medio-lateral ray by a rather wide cleft; vulva not protuberant; male 12 to 16 mm. long, female 14 to 18 mm. long..... *Æsophagostomum columbianum*, p. 41
 Mouth collar flattened, disk-like in shape, its height a little more than one-fourth its diameter; externo-lateral ray of the bursa closely approximated to the medio-lateral ray; stem of the lateral rays with a dorsal projection at the root of the postero-lateral ray; vulva protuberant; male 14 to 17 mm. long, female 16 to 22 mm. long..... *Æsophagostomum radiatum*, p. 44

Æsophagostomum columbianum (Curtice, 1890) Stossich, 1899.

(Figs. 18-22.)

1890: *Æsophagostoma columbianum* Curtice, 1890c, pp. 16, 17, 20, 21, 22, 118, 145, 161, 165-180, pls. 24-27 (from sheep, United States).

1899: *Æsophagostomum columbianum* (Curtice) Stossich, 1899d, p. 96.

SPECIFIC DIAGNOSIS.—*Æsophagostomum* (p. 40): Length of body averages about 40 times its maximum thickness. Thickness of body nearly uniform in the middle three-fifths, becoming less toward both ends. Anterior portion of body commonly bent into a hook. Mouth collar (*m. c.*, fig. 19) hemispherical or truncate hemispherical in shape; its height a little less than half its diameter; two crowns of leaf-like processes, about twenty-four in each crown. Transverse cervical groove (*c. g.*, fig. 19) and its accompanying cuticular fold, well marked ventrally, become obliterated after crossing the lateral lines. Cuticle between the cervical groove and the head only very slightly inflated. Cervical papillæ (*c. p.*, fig. 19) in front of the middle of the esophagus. Well developed lateral membranes (*l. m.*, fig. 19) beginning at the cervical groove extend nearly the entire length of the body in both sexes.

Male 12 to 16 mm. long. Tips of the ventral (*v. v.*, *l. v.*, figs. 20, 21), medio-lateral (*m. l.*, figs. 20, 21), and postero-lateral (*p. l.*, figs. 20, 21) rays and the inner division (*t. d.*, fig. 20) of each of the two main branches of the dorsal ray (*d.*, figs. 20, 21) reach the edge of the bursa. Tips of the externo-dorsal (*e. d.*, figs. 20, 21) and externo-lateral (*e. l.*, figs. 20, 21) rays at about equal distances from the border of the bursa. Externo-lateral ray separated from the medio-lateral ray by a rather wide cleft. Distance between the tip of the externo-dorsal ray and the tip of the externo-lateral ray slightly greater than the distance between the latter and the tips of the ventral rays. Externo-dorsal rays take origin from the dorsal ray about halfway between its root and its bifurcation. Outer division of each main branch of the dorsal ray less than half as long as the inner division, but thicker. Spicules (*sp.*, fig. 20) 750 to 850 μ in length. Gubernaculum about 100 μ long.

Female 14 to 18 mm. long. Posterior 2 or 3 mm. of body tapers gradually to the pointed tip of the tail (fig. 22). Anus (*an.*, fig. 22) a little more than 0.3 mm. from the tip of the tail; vulva about 1 mm. Vulva (*vul.*, fig. 22) elliptical, transversely elongated

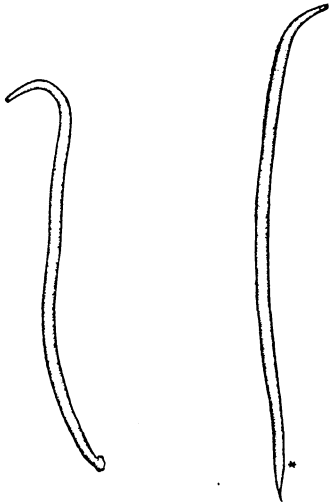


FIG. 18.—*Cesophagostomum columbianum*. Male at left, female at right. * Vulva. $\times 5$. (Original.)

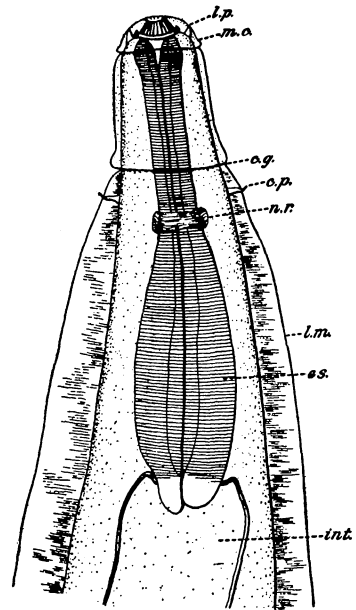


FIG. 19.—*Cesophagostomum columbianum*. Anterior end of body. Ventral view. c. g., cervical groove; c. p., cervical papilla; es., esophagus; int., intestine; l. m., lateral membrane; l. p., lateral circumoral papilla; m. c., mouth collar; n. r., nerve ring. $\times 75$. (Original.)

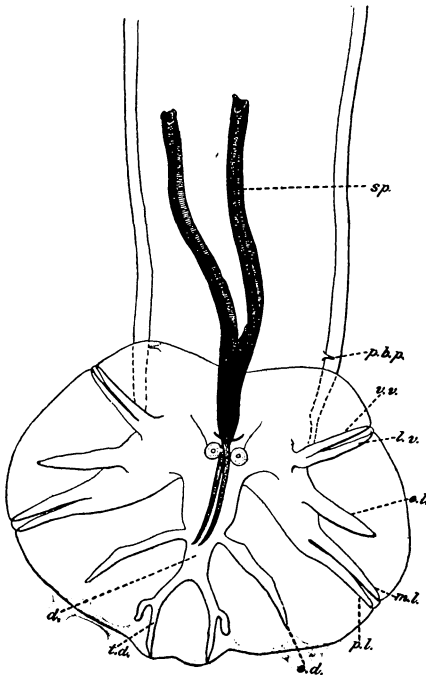


FIG. 20.—*Cesophagostomum columbianum*. Posterior end of body of male with bursa spread out. Ventral view. d., dorsal ray; e. d., externo-dorsal ray; e. l., externo-lateral ray; l. v., latero-ventral ray; m. l., medio-lateral ray; p. b. p., pre-bursal papilla; p. l., postero-lateral ray; sp., spicule; t. d., terminal branch of dorsal ray; v. v., ventro-ventral ray. $\times 75$. (Original.)

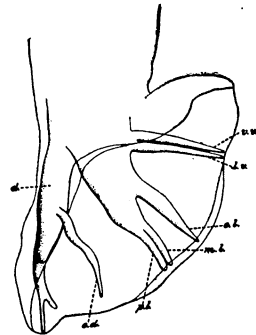


FIG. 21.—*Cesophagostomum columbianum*. Bursa of male viewed from right side. d., dorsal ray; e. d., externo-dorsal ray; e. l., externo-lateral ray; l. v., latero-ventral ray; m. l., medio-lateral ray; p. l., postero-lateral ray; v. v., ventro-ventral ray. $\times 75$. (Original.)

not raised above the surface of the body. Vagina (*vag.*, fig. 22) less than 100μ long. Combined length of the muscular portions of the two ovijectors (*ovij.*, fig. 22) including the sphincters about 230μ . Eggs 65 by 40μ to 75 by 45μ in diameter.

HOSTS.—*Sheep (*Ovis aries*); *goat (*Capra hircus*); ?cattle (*Bos taurus*).

LOCATION.—Large intestine.

LOCALITIES COLLECTED.—United States, Australia.

This species is a very common parasite of sheep in the United States. It is the cause of the so-called nodular disease of the intestine. The nodules mark the location of larval stages of the parasite which live embedded in the wall of the intestine into which they penetrate after being swallowed by the host. In the early stage of the development of the larva the nodule is very small, but gradually increases in size, becoming filled with a mass of greenish cheesy material upon which, apparently, the larva feeds. When the larva has undergone a certain amount of growth and development it abandons the nodule and enters the lumen of the intestine, where it completes its development to maturity. The nodules are most common in the wall of the cecum, but may occur in other portions of the intestine and in the liver and other abdominal viscera.

Nodular disease is more or less injurious according to the extent of infestation, age, and individual vitality of the animals infested. Affected intestines are excluded from use as sausage casings.

There is no known effective medicinal treatment for this parasite. Lambs may be protected from serious infestation if raised by the so-called "bare-lot" method, in which the lambs and ewes are kept in inclosures free from vegetation, and fed and watered from racks and troughs arranged so that they can not be contaminated by the feces of the infested ewes.

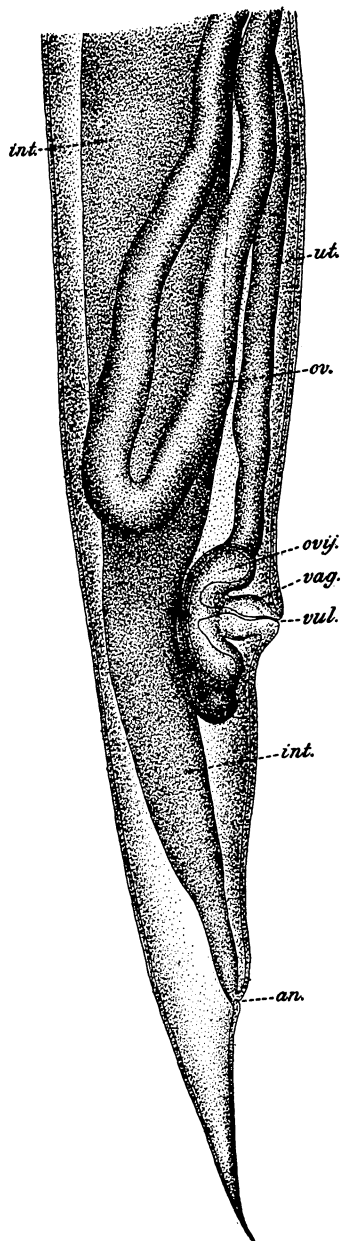


FIG. 22.—*Esophagostomum columbianum*. Posterior end of body of female viewed from right side. *an.*, anus; *int.*, intestine; *ov.*, ovary; *ovij.*, ovijector; *ut.*, uterus; *vag.*, vagina; *vul.*, vulva. $\times 75$. (Original.)

Esophagostomum columbianum has been reported as a parasite of cattle, but the correctness of the identification seems questionable. All of the specimens of *Esophagostomum* from cattle which I have examined have been *Æ. radiatum*. In any event *Æ. columbianum*, if it occurs at all in cattle, is of rather rare occurrence in that host in this country.

***Esophagostomum radiatum* (Rudolphi, 1803) Railliet, 1898.**

(Figs. 23-27.)

- 1803: *Strongylus radiatus* Rudolphi, 1803a, pp. 13-15 (from *Bos taurus*, Europe).
 1866: *Strongylus inflatus* Schneider, 1866a, pp. 129, 131, 139, 141 (from *Bos taurus*) (not *S. inflatus* Molin, 1861a, pp. 520-521, pl. 5, figs. 7, 8; from *Myrmecophaga jubata*).
 1884: *Strongylus dilatatus* Railliet, 1884. (*Strongylus inflatus* Schneider, 1866, renamed).
 1885: *Esophagostoma inflatum* (Schneider) Railliet, 1885a, pp. 346-347, fig. 235.
 1896: *Esophagostomum dilatatum* (Railliet) Railliet, 1896d, p. 160.
 1896: *Esophagostomum inflatum* (Schneider) Railliet, 1896d, p. 160.
 1898: *Esophagostomum radiatum* (Rudolphi) Railliet, 1898c, p. 254.
 1906: *Esophagostomum bovis* Schnyder, 1906b, pp. 182, 183, 197.

SPECIFIC DIAGNOSIS.—*Esophagostomum* (p. 40): Length of body averages about 40 times its maximum thickness. Thickness of body nearly uniform in its middle three-fifths, becoming less toward both ends. Anterior end commonly bent into a hook. Mouth collar (*m. c.*, fig. 24) flattened, disk-like, its height a little more than one-fourth its diameter; a single crown of numerous small triangular denticles at the anterior border of the mouth capsule; leaf-like processes lacking. Cervical groove (*c. g.*, fig. 24) and cuticular fold well marked, continuing around the body, the fold projecting farther backward on the dorsal and ventral surfaces than on the lateral surfaces. Cuticle inflated (*c. i.*, fig. 24) between the mouth collar and the cervical groove. At about one-third the distance from the cervical groove to the head the inflated cuticle is constricted by a shallow annular groove (*c. a.*, fig. 24). Cervical papillæ (*c. p.*, fig. 24) opposite the middle of the esophagus. Well developed lateral membranes (*l. m.*, fig. 24) beginning at the cervical groove extend nearly the entire length of the body in both sexes. Lumen of esophagus has an infundibuliform enlargement at its beginning about 75 μ long.

Male 14 to 17 mm. long. Tips of the ventral (*v. v.*, *l. v.*, figs. 25, 26), medio-lateral (*m. l.*, figs. 25, 26), and postero-lateral (*p. l.*, figs. 25, 26) rays, and the inner division (*i. d.*, figs. 25, 26) of each of the two main branches of the dorsal ray (*d.*, figs. 25, 26) reach the edge of the bursa. Tips of the externo-dorsal (*e. d.*, figs. 25, 26) and the externo-lateral (*e. l.*, figs. 25, 26) rays at about equal distances from the border of the bursa. Lateral rays come off from the external surface of their common stem (*l. t.*, figs. 25, 26) which projects dorsally, forming a protuberance (*d. h.*, figs. 25, 26) at the root of the postero-lateral ray. Externo-lateral ray closely approximated to the medio-lateral ray, separated from it by a narrow cleft. Distal portion of externo-lateral ray curved ventrally away from the medio-lateral ray. Distance between the tips of the externo-dorsal ray and the externo-lateral ray slightly greater than the distance between the latter and the tips of the ventral rays. Externo-dorsal rays take origin from the dorsal ray less than halfway between its root and its bifurcation. Outer division of each main branch of the dorsal ray less than one-half the length of the inner division. Spicules 700 to 800 μ long. Gubernaculum about 115 μ long.

Female 16 to 22 mm. long. Behind the vulva the body rapidly diminishes in thickness, then tapers more gradually to the tip of the slender tail (fig. 27). Tail curved ventralward. Anus (*an.*, fig. 27) a little more than 0.3 mm. from the tip of the tail; vulva about 1 mm. Vulva (*vul.*, fig. 27) elliptical, transversely elongated, raised on a prominently projecting rounded papilla. Vagina less than 150 μ long. Combined

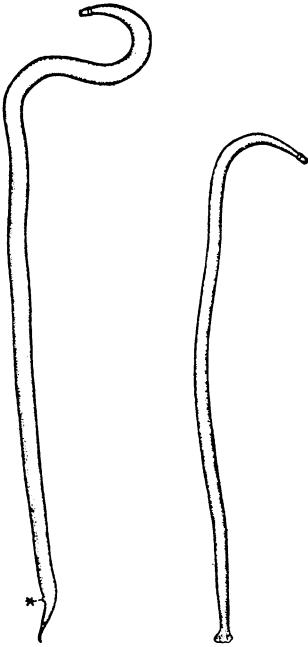


FIG. 23.—*Esophagostomum radiatum*. Male at right, female at left. *Vulva. $\times 5$. (Original.)

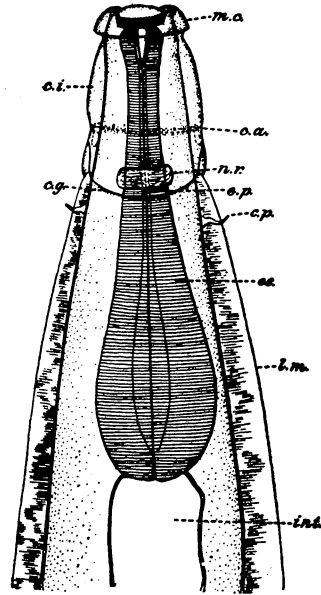


FIG. 24.—*Esophagostomum radiatum*. Anterior end of body. Ventral view. c. a., annular groove surrounding cervical inflation of cuticle; c. g., cervical groove; c. i., cervical inflation; c. p., cervical papilla; e. p., excretory pore; es., esophagus; int., intestine; l. m., lateral membrane; m. c., mouth collar; n. r., nerve ring. $\times 75$. (Original.)

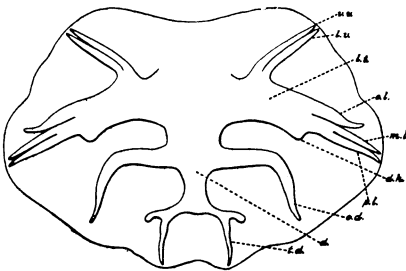


FIG. 25.—*Esophagostomum radiatum*. Bursa of male spread out. d., dorsal ray; d. h., dorsal projection of trunk of lateral rays at base of postero-lateral ray; e. d., externo-dorsal ray; e. l., externo-lateral ray; l. v., latero-ventral ray; l. t., trunk of lateral rays; m. l., medio-lateral ray; p. l., postero-lateral ray; t. d., terminal branch of dorsal ray; v. v., ventro-ventral ray. $\times 75$. (Original.)

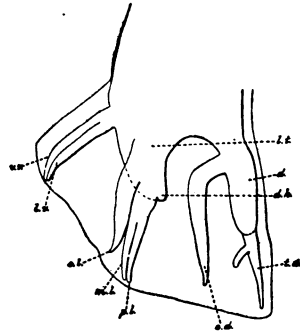


FIG. 26.—*Esophagostomum radiatum*. Bursa of male, viewed from left side. d., dorsal ray; d. h., dorsal projection of trunk of lateral rays at base of postero-lateral ray; e. d., externo-dorsal ray; e. l., externo-lateral ray; l. t., trunk of lateral rays; l. v., latero-ventral ray; m. l., medio-lateral ray; p. l., postero-lateral ray; t. d., terminal branch of dorsal ray; v. v., ventro-ventral ray. $\times 75$. (Original.)

length of the muscular portions of the two ovijectors (*ovij.*, fig. 27) including the sphincters about 250μ . Eggs (*e.*, fig. 27) 75 by 40μ to 85 by 45μ in diameter.

HOST.—*Cattle (*Bos taurus*).

LOCATION.—Large intestines.

LOCALITIES COLLECTED.—United States, Europe, Australia.

In this species, as in *Æ. columbianum*, a portion of the larval stage is passed in nodules formed in the wall of the intestines. The location of the nodules is apparently more often the small intestine than the large intestine, just the opposite to *Æ. columbianum*.

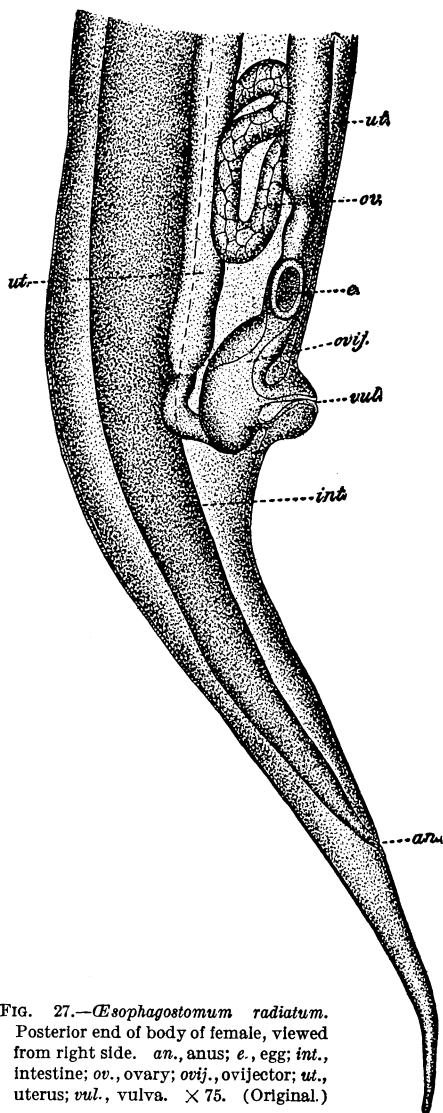


FIG. 27.—*Esophagostomum radiatum*. Posterior end of body of female, viewed from right side. *an.*, anus; *e.*, egg; *int.*, intestine; *ov.*, ovary; *ovij.*, ovijector; *ut.*, uterus; *vul.*, vulva. $\times 75$. (Original.)

***Esophagostomum venulosum* (Rudolphi, 1809) Railliet, 1896.**

(Figs. 28-32.)

1809: *Strongylus venulosus* Rudolphi, 1809a, pp. 221-222 (from *Capra hircus*, Europe).

1819: *Strongylus amimonis* Rudolphi, 1819a, p. 37.

1845: *Strongylus radiatus* Rudolphi of Dujardin, 1845a, pp. 125-126 (in part).

1851: *Strongylus contortus* Rudolphi of Diesing, 1851a, p. 318 (misdetermination).

1861: *Esophagostomum acutum* Molin, 1861a, p. 449.

1885: *Esophagostoma venulosum* (Rudolphi) Railliet, 1885a, pp. 347-348.

1887: *Esophagostoma inflatum* var. *ovis* Carita, 1887a, p. 60.

1896: *Esophagostomum venulosum* (Rudolphi) Railliet, 1896m, p. 490.

SPECIFIC DIAGNOSIS.—*Esophagostomum* (p. 40): Length of body 30 to 35 times its maximum thickness. Thickness of body nearly uniform in the middle three-fifths, becoming less toward both ends. Anterior end of body usually straight. Height of mouth collar (*m. c.*, fig. 29) about one-third its diameter; shape truncate conical; two crowns of leaf-like processes; not more than 16 processes in each crown. Cervical groove (*c. g.*, fig. 29) usually does not extend dorsal of the lateral lines, but may in some cases be traced entirely around the body. Cuticle of neck inflated (*c. i.*, fig. 29) between the mouth collar and the cervical groove. Cervical papillæ (*c. p.*, fig. 29) post-esophageal. Lateral membranes (*l. m.*, fig. 29) extend nearly the entire length of the body, but are very narrow throughout their course.

cate conical; two crowns of leaf-like processes; not more than 16 processes in each crown. Cervical groove (*c. g.*, fig. 29) usually does not extend dorsal of the lateral lines, but may in some cases be traced entirely around the body. Cuticle of neck inflated (*c. i.*, fig. 29) between the mouth collar and the cervical groove. Cervical papillæ (*c. p.*, fig. 29) post-esophageal. Lateral membranes (*l. m.*, fig. 29) extend nearly the entire length of the body, but are very narrow throughout their course.

Male 11 to 16 mm. long. Tips of the ventral (*v. v.*, *l. v.*, figs. 30, 31), medio-lateral (*m. l.*, figs. 30, 31), and postero-lateral (*p. l.*, figs. 30, 31) rays, and the inner division (*t. d.*, fig. 30) of each of the two main branches of the dorsal ray (*d.*, figs. 30, 31) reach the edge of the bursa. Tips of the externo-dorsal (*e. d.*, figs. 30, 31) and externo-lateral (*e. l.*, figs. 30, 31) rays at about equal distances from the edge of the bursa. Externolateral ray separated from the medio-lateral ray by a rather wide cleft. Distance between the tip of the externo-dorsal ray and the tip of the externo-lateral ray slightly less than the distance between the latter and the tips of the ventral rays. Externodorsal rays take origin from the dorsal ray about halfway between its root and its bifurcation. Outer division of each main branch of the dorsal ray about half as long as the inner division, and reaching nearly to the border of the bursa. Spicules (*sp.*, fig. 31) 1.1 to 1.5 mm. long. Gubernaculum 90 to 100 μ long.

Female 13 to 24 mm. long. Body tapers from a short distance in front of the vulva to the tip of the sharply pointed tail, which is commonly bent dorsalward. Anus (*an.*, fig. 32) 150 to 200 μ , vulva 375 to 500 μ , from the tip of the tail. Vulva (*vul.*, fig. 32) elliptical, transversely elongated, more or less protuberant. Vagina (*vag.*, fig. 32) 400 to 600 μ long. Combined length of the muscular portions of the two ovijectors (*ovij.*, fig. 32) including the sphincters 250 to 300 μ . Eggs 85 by 45 μ to 100 by 55 μ in diameter.

HOSTS.—* Goat (*Capra hircus*); * sheep (*Ovis aries*); * fallow deer (*Dama dama*); roe deer (*Capreolus capreolus*); argali (*Ovis ammon*); chamois (*Rupicapra rupicapra*); Arabian camel (*Camelus dromedarius*).

LOCATION.—Large intestine, more rarely small intestine and stomach.

LOCALITIES COLLECTED.—Europe and United States.

This species, commonly reported as a parasite of sheep and goats in Europe, is much less common in those hosts in this country than *E. columbianum*.

Subfamily METASTRONGYLINÆ¹ Leiper, 1908.

SUBFAMILY DIAGNOSIS.—Strongylidæ (p. 26): Mouth cavity very small, not enlarged to form a buccal capsule.

TYPE GENUS.—*Metastrongylus* Molin, 1861.

Five genera of this subfamily are represented among the nematodes parasitic in the alimentary tract of ruminants.

KEY TO GENERA OF METASTRONGYLINÆ.

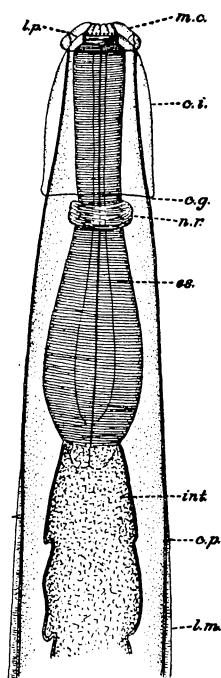
(The imperfectly known species (?*Hæmonchus*) *bispinosus*, p. 54, *Strongylus ventricosus*, p. 98, and *Strongylus fordii*, p. 99, though evidently belonging in the subfamily Metastrongylinæ, are not included in this and following keys.)

1. Mouth cavity containing a single buccal tooth or lancet; well developed cervical papillæ or spines present; bursa of male with two large lateral lobes, and a small asymmetrical dorsal lobe; gubernaculum present; both sexes 10 mm. or more in length..... *Hæmonchus*, p. 49
- No buccal teeth or lancets in mouth cavity; cervical papillæ present or absent; dorsal lobe or dorsal lobules of bursa symmetrical in position; gubernaculum of spicules present or absent..... 2
2. Tip of latero-ventral ray of bursa closer to tip of externo-lateral ray than to tip of ventro-ventral ray; ventro-ventral ray much smaller than latero-ventral ray; head about 10 μ in diameter; both sexes less than 10 mm. in length; cervical papillæ absent; spicules less than 200 μ long; gubernaculum present.

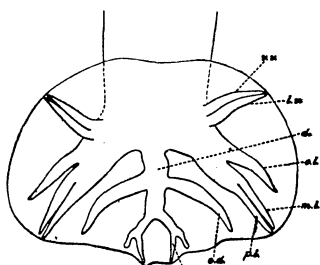
Trichostrongylus, p. 86

- Tip of latero-ventral ray of bursa closer to tip of ventro-ventral ray than to tip of externo-lateral ray..... 3

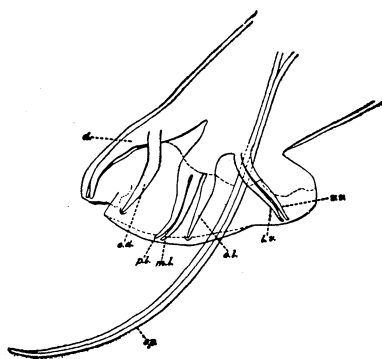
¹ See Addendum, p. 124.



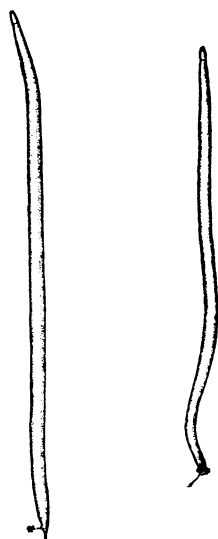
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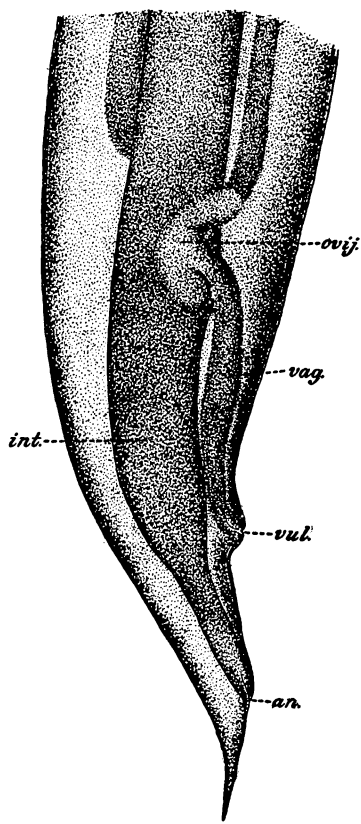
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31



28



32

3. Head less than 25μ in diameter; cervical papillæ present; tips of ventro-ventral and latero-ventral rays of each lateral lobe of bursa close together; a small accessory bursal membrane attached to the posterior end of the body toward its dorsal side, inside the bursa; gubernaculum present or absent.....*Ostertagia*, p. 54
 Head over 25μ in diameter; cervical papillæ absent; no accessory bursal membrane; gubernaculum lacking..... 4
4. Ventro-ventral and latero-ventral rays of each lateral lobe of bursa close together, parallel; 2 dorsal rays; dorsal lobe of bursa divided into two lobules each supported by one of the dorsal rays; spicules tubular, filiform, over 0.5 mm. long.....*Nematodirus*, p. 82
 Ventro-ventral and latero-ventral rays of bursa divergent, their tips rather widely separated; unpaired median dorsal ray divides distally into two branches, parallel or forming a lyre-shaped structure; spicules short, thick, less than 0.5 mm. long.....*Cooperia*, p. 69

Genus *HÆMONCHUS* Cobb, 1898.

1898: *Hæmonchus* Cobb, 1898a, p. 447.

GENERIC DIAGNOSIS.—*Metastrongylinae* (p. 47): Head less than 50μ in diameter, with inconspicuous circumoral papillæ. The small mouth cavity contains a slender tooth or lancet originating from the dorsal side of its base. Cuticle of head and neck not inflated. A well developed cervical spine in each lateral line of the body in the esophageal region. Bursa of male with large lateral lobes and a small dorsal lobe not in the median line but attached to one of the lateral lobes near its base. Dorsal ray supporting the dorsal lobe divided distally into two branches. Six rays in each lateral lobe. Ventral rays of each lateral lobe separated distally, curving forward. Medio-lateral and postero-lateral rays distally curve backward or dorsalward away from the externo-lateral ray. Externo-dorsal ray long and slender. Prebursal papillæ present. Spicules relatively short, less than 1 mm. long. Gubernaculum present. Vulva of female in posterior portion of the body covered by a prominent linguiform process which projects backward. Ovijectors well developed. Eggs ellipsoidal, with thin shells.

TYPE SPECIES.—*Hæmonchus contortus* (Rudolphi, 1803) Cobb, 1898.

Two species belonging to the genus *Hæmonchus* are represented among the nematodes parasitic in ruminants, to which a third of uncertain identity has been provisionally added by Railliet and Henry (1909a).

FIG. 28.—*Esophagostomum venulosum*. Male at right, female at left. *Vulva. $\times 5$. (Original.)

FIG. 29.—*Esophagostomum venulosum*. Anterior end of body. Ventral view. *c. g.*, cervical groove; *c. i.*, cervical inflation; *c. p.*, cervical papilla; *es.*, esophagus; *int.*, intestine; *l. m.*, lateral membrane; *l. p.*, lateral circum-oral papilla; *m. c.*, mouth collar; *n. r.*, nerve ring. $\times 75$. (Original.)

FIG. 30.—*Esophagostomum venulosum*. Bursa of male spread out. *d.* dorsal ray; *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *t. d.*, terminal branch of dorsal ray; *v. v.*, ventro-ventral ray. $\times 75$. (Original.)

FIG. 31.—*Esophagostomum venulosum*. Bursa of male viewed from right side. *d.*, dorsal ray; *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *sp.*, spicules; *v. v.*, ventro-ventral ray. $\times 75$. (Original.)

FIG. 32.—*Esophagostomum venulosum*. Posterior end of body of female viewed from right side. *an.*, anus; *int.*, intestine; *ovij.*, ovijector; *vag.*, vagina; *vul.*, vulva. $\times 75$. (Original.)

KEY TO SPECIES OF *HÆMONCHUS*.

(The imperfectly known (?*Hæmonchus*) *bispinosus*, p. 54, is not included in this key.)

- Stem of the ray of the asymmetrical dorsal lobe of the bursa less than twice as long as its branches; spicules of male 300 to 500 μ long; male 10 to 20 mm. long, female 18 to 30 mm. long.....*Hæmonchus contortus*, p. 50.
- Stem of the ray of the asymmetrical dorsal lobe of the bursa twice as long as its branches; spicules of male about 625 μ long; male 20 to 21 mm. long, female 26 to 29 mm. long.....*Hæmonchus longestipes*, p. 54.

***Hæmonchus contortus* (Rudolphi, 1803) Cobb, 1898.**

(Figs. 33-37.)

1803: *Strongylus contortus* Rudolphi, 1803a, pp. 15-17 (from *Ovis aries*, Europe).

1861: *Strongylus filicollis* Rudolphi of Molin, 1861a, pp. 512-513 (misdetermination).

1893: *Strongylus placei* Place, 1893, Vet. Rec., Lond. (250), v. 5, Apr. 22, p. 589 ("strongyle-like worms 1-3 centimeters in length" from the abomasum of a calf).

1898: *Hæmonchus contortus* (Rudolphi) Cobb, 1898a, p. 447, fig. 120.

SPECIFIC DIAGNOSIS.—*Hæmonchus* (p. 49): Head (fig. 34) about 30 μ in diameter. Buccal lancet 10 to 15 μ long may project slightly through the opening of the mouth. Cervical spines (c. p., fig. 34) about 0.3 mm. from the anterior end of the body. Esophagus (es., fig. 34) claviform, about 1.5 mm. long. Diameter of body at base of esophagus about 180 μ .

✓ Male 10 to 20 mm. long. Maximum thickness about 400 μ in the posterior portion of the body, some distance in front of the bursa. Anteriorly the body is gradually attenuated. Lateral lobes of bursa (fig. 35) large, 600 to 700 μ long by 300 to 400 μ wide. The asymmetrically situated dorsal lobe is attached to the left lateral lobe on its inner side near its base and measures about 150 μ long by 125 μ wide. Dorsal ray (d., fig. 35) supporting the dorsal lobe, distally divides into two branches, each of which is bifurcated at its extremity. Stem of dorsal ray slightly longer than its branches. Dorsal ray takes its origin from the left common trunk of the rays, near the point of origin of the left externo-dorsal ray. Paired rays parallel and close together for some distance beyond their origin from the common trunk. Ventral rays fused proximally are separated distally, curving ventralward, and both extending nearly to the edge of the bursa. The ventro-ventral ray (v. v., fig. 35) is narrower than the latero-ventral ray (l. v., fig. 35) and shorter. The lateral rays originate from the common trunk in a common stem dividing distally into three. The externo-lateral ray (e. l., fig. 35) is almost straight, extending nearly to the edge of the bursa. The latero-ventral and externo-lateral rays are about equal in thickness, thicker than any of the other rays. The medio-lateral (m. l., fig. 35) and postero-lateral (p. l., fig. 35) rays curve dorsalward in their distal portion, diverging from one another slightly at their tips and nearly reaching the edge of the bursa. Externo-dorsal ray (e. d., fig. 35), slenderest and longest of the rays, nearly straight, slightly curved dorsalward in its distal portion, originates from the common trunk of the rays near the base of the lateral lobe of the bursa. It reaches nearly to the edge of the bursa, but its tip is usually at a slightly greater distance from the edge than the tips of the other rays. The tips of the medio-lateral and postero-lateral rays are closer together than the tips of any other two contiguous rays; tips of the ventral rays next, then the tips of the postero-lateral and externo-dorsal rays, and finally the tips of the externo-lateral and latero-ventral are more widely separated than the tips of any other two contiguous rays. Spicules (sp., fig. 35) 300 to 500 μ long, reduced in size from before backward, with small knobbed tips; left spicule with a barb-like projection about 20 μ from the posterior end, right spicule with a similar projection about 40 μ from the posterior end. Gubernaculum (gub., fig. 35) about 200 μ long by 25 to 30 μ broad, flat, fusiform, with thickened edges.

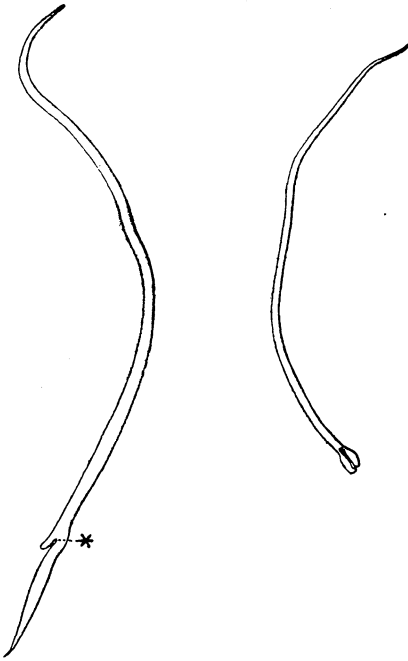


FIG. 33.—*Hæmonchus contortus*. Male at right, female at left. *Vulva. $\times 5$. (Original.)

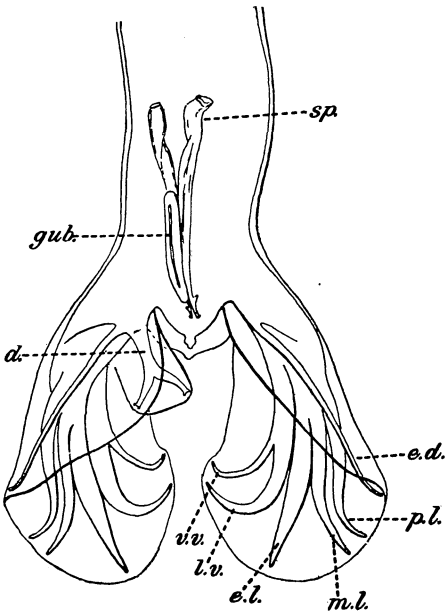


FIG. 35.—*Hæmonchus contortus*. Posterior end of body of male. Dorsal view. *d.*, dorsal ray supporting the asymmetrically situated dorsal lobe of bursa; *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *gub.*, gubernaculum; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *sp.*, spicule; *v. v.*, ventro-ventral ray. $\times 75$. (Original.)

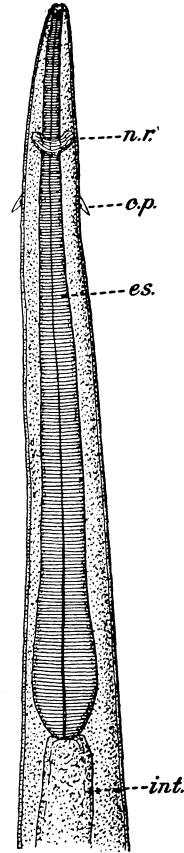


FIG. 34.—*Hæmonchus contortus*. Anterior end of body. *c. p.*, cervical papilla; *es.*, esophagus; *int.*, intestine; *n. r.*, nerve ring. $\times 75$. (Original.)

Female 18 to 30 mm. long by about 0.5 mm. in maximum thickness a short distance in front of the vulva. Body more gradually attenuated toward the anterior extremity than toward the posterior extremity. Vulva (*vul.*, fig. 36) 3 to 4.5 mm. from the tip of the tail, covered by a prominent backward projecting linguiform process (*lab.*, fig. 36) about 0.5 mm. long. Combined length of muscular portions of ovijectors (*ovij.*, fig. 36), including the sphincters, about 1 mm. Ovaries (*ov.*, figs. 36, 37)

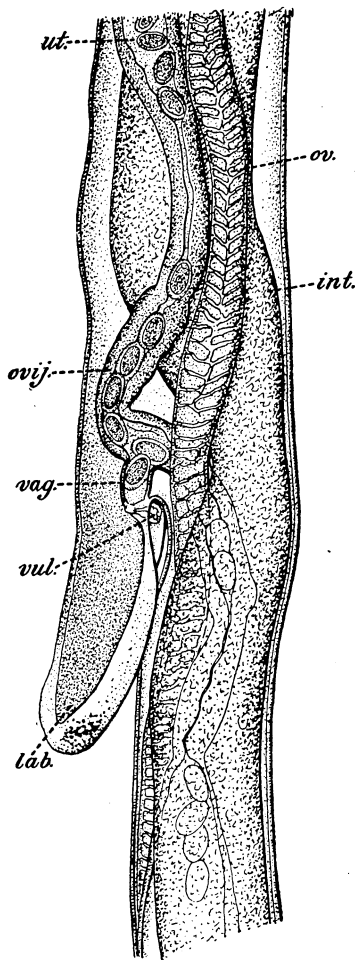


FIG. 36.—*Hæmonchus contortus*. Body of female in region of vulva, viewed from left side. *int.*, intestine; *lab.*, linguiform process covering vulva; *ov.*, ovary; *ovij.*, ovijector; *ut.*, uterus; *vag.*, vagina; *vul.*, vulva. $\times 75$. (Original.)

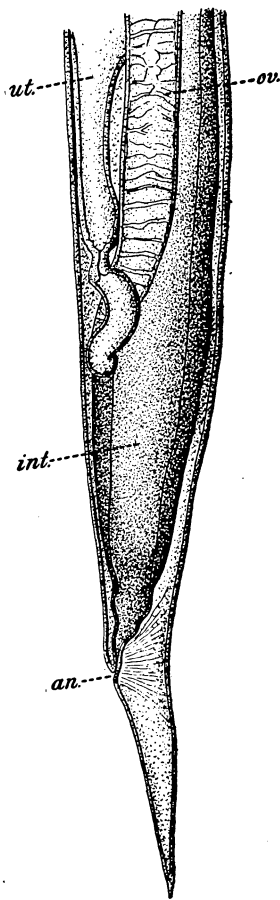


FIG. 37.—*Hæmonchus contortus*. Posterior end of body of female, viewed from left side. *an.*, anus; *int.*, intestine; *ov.*, ovary; *ut.*, uterus. $\times 75$. (Original.)

wound spirally around the intestine. Anus (*an.*, fig. 37) 400 to 630 μ from the tip of the tail. Tail slender, acutely pointed, diameter at anus about 100 μ . Eggs 75 to 95 μ long by 40 to 50 μ wide, segmenting when laid.

Hosts.—*Cattle (*Bos taurus*): *sheep (*Ovis aries*); *goat (*Capra hircus*); addax (*Addax nasomaculatus*); *moose (*Alce americanus*); *prong-horned antelope (*Antilocapra americana*); chamois (*Rupicapra rupicapra*); *American bison (*Bison bison*); *roe deer (*Capreolus capreolus*); *mule deer (*Odocoileus hemionus*); *deer (*Mazama sp.*);

man (*Homo sapiens*); *bharal (*Ovis nahuja*); argali (*Ovis ammon*); *Mexican mountain sheep (*Ovis mexicana*); *Newfoundland caribou (*Rangifer terrænovæ*).

LOCATION.—Fourth stomach, more rarely other compartments of the stomach, and intestine.

LOCALITIES COLLECTED.—Europe, United States, Asia, Africa, Australia, South America, New Zealand.

Hæmonchus contortus is one of the commonest parasites of sheep, and when numerous is very injurious. It evidently feeds upon the blood of its host, attacking the mucous membrane of the fourth stomach by means of its buccal tooth. Heavy infestation leads to anemia, dropsy, emaciation, and irregularities of digestion. Many lambs are killed every year by this parasite.

In another paper (Ransom, 1906i, B. A. I. Circular 93) it has been shown that *Hæmonchus contortus* undergoes a direct development without intermediate host. The eggs passed in the feces of the host hatch in a few hours, days, or weeks, according to the temperature. Dryness or a freezing temperature kills the eggs and newly hatched larvæ in a short time. The newly hatched larva has an esophagus with a posterior bulb containing a masticatory apparatus, and it feeds upon the fecal matter in which it lives. Within a few days or weeks, the length of time required varying according to the temperature, the larva develops into the final free-living stage, which has a simple claviform esophagus without posterior bulb. In this stage the larva is closely enveloped by a thin chitinous sheath, and apparently is no longer able to ingest food, depending for its nourishment upon material stored up in the cells of the intestine. The ensheathed larva is motile at temperatures above 40° F., and becomes more active as the temperature becomes higher. Unlike newly hatched larvæ and eggs, the ensheathed larva can withstand freezing and drying for long periods, and may survive several months in the dried condition, afterwards reviving on the addition of moisture. When the air is sufficiently damp for moisture to be precipitated as dew or rain, the ensheathed larvæ crawl up grass blades or other objects, coming to rest when the moisture evaporates and resuming their migration when the air again becomes damp, and thus gradually work their way higher and higher from the ground. When swallowed by a sheep or other ruminant the ensheathed larva continues its development toward maturity and becomes a full grown adult in two or three weeks.

Methods of treatment of sheep infested with this parasite are described in B. A. I. Circular 102 (Ransom, 1907b).

The best means of controlling this parasite seems at present to be the rotation of pastures, changing the flock to fresh pasture as frequently as possible, taking care not to overstock, and keeping sheep and cattle out of each pasture for at least a year before it is used again, so that infection in the pasture may have time to die out.

Hæmonchus contortus has been reported once as a parasite of man in South America, but this undoubtedly was a purely accidental occurrence. It does not occur in horses, rabbits, or pigs, and is clearly a parasite which is normally restricted to ruminants. Pastures from which sheep and cattle have been removed in order for infection to die out may accordingly be used for horses and pigs without danger of keeping up the infection.

***Hæmonchus longistipes* Railliet and Henry, 1909.**

1909: *Hæmonchus longistipes* Railliet and Henry, 1909a, p. 86 (from *Camelus dromedarius*, Africa, India).

SPECIFIC DIAGNOSIS.—*Hæmonchus* (p. 49): Male 20 to 21 mm. long. Spicules 625μ long. Bursa with an asymmetrical dorsal lobe supported by a ray whose trunk is twice as long as its distal branches.

Female 26 to 29 mm. long.

HOST.—Arabian camel (*Camelus dromedarius*).

LOCATION.—Fourth stomach.

LOCALITIES COLLECTED.—Africa and India.

The foregoing diagnosis is taken from the brief description of Railliet and Henry (1909a).

(? *Hæmonchus*) *bispinosus* (Molin, 1860) Railliet and Henry, 1909.

1860: *Strongylus bispinosus* MOLIN, 1860e, p. 351 (from *Cervus nambi* (= *Mazama nana*), Brazil).

1909: (? *Hæmonchus*) *bispinosus* (Molin) Railliet and Henry, 1909a, p. 86.

SPECIFIC DIAGNOSIS.—*Hæmonchus* (p. 49): Head continuous with the body, not alate. Mouth with unarmed border. Body filiform; anterior end of body gradually attenuated, with two strong cervical spines.

Male 10 mm. long by 0.2 mm. thick. Tail of male curved, provided with a trilobed copulatory bursa. Lateral lobes very long, supported by 5 rays, the middle one of which is straight; the other rays diverge from the middle ray, and are curved at the tips. Median lobule of bursa with two rays. Spicules with long styloid shanks. Sheath of spicules very long, filiform.

Female 17 mm. long by 0.3 mm. thick. Tail long, subulate. Anus remote from tip of tail. Vulva in posterior portion of body, large, bilabiate, with limbiform anterior lip, and pendulous posterior lip, swollen to form a large vesicle. Uterus bicornate.

HOST.—Pygmy brocket (*Mazama nana*).

LOCATION.—Stomach.

LOCALITY COLLECTED.—Brazil.

Nothing is known concerning this species beyond the brief descriptions given by Molin (1860e, 1861a, p. 514) from which the foregoing diagnosis is taken.

Genus *OSTERTAGIA* Ransom, 1907.

1907: *Ostertagia* Ransom, 1907k, p. 2.

GENERIC DIAGNOSIS.—*Metastrongylinæ* (p. 47): Head less than 25μ in diameter, with six indistinct lips or papillæ surrounding the mouth. Mouth cavity small. Cervical papillæ present. Cuticle marked with 25 to 35 longitudinal ridges appearing as simple lines, except under high magnification when they sometimes show a finely beaded appearance. Cuticle of head may be slightly dilated, forming a narrow collar

or annulus. Bursa with two lateral lobes united by a smaller median lobe. Each lateral lobe supplied with six supporting rays. The two ventral rays are close together and their tips are in relation with a more or less conspicuous indentation of the edge of the bursa. The tips of the medio-lateral, postero-lateral and externo-dorsal rays are in relation with the posterior border of the bursa. The dorsal ray separates into two main branches which may divide distally into two short branches or give off one or two short side branches internally or externally. Attached to the posterior end of the body of the male toward the dorsal side and inside the bursa there is an accessory bursal membrane with a free posterior edge supported by two slender diverging rays. The spicules are short (less than 1 mm. in length), similar in size and shape, and are divided lengthwise in the distal portion into two or three processes. An accessory piece or gubernaculum may be present or absent. When present it is inconspicuous, colorless and drawn out into a slender process posteriorly. Prebursal papillæ present. Vulva less than one-fifth the length of the body from the posterior end, naked or covered by a thin, backward projecting, cuticular flap. Ovijectors well developed. Eggs oval, with thin shells.

TYPE SPECIES.—*Ostertagia ostertagi* (Stiles, 1892) Ransom, 1907.

Seven species of *Ostertagia* are known to occur in ruminants, and all but one of these have been found in America.

KEY TO SPECIES OF OSTERTAGIA.

1. Spicules of male about 700μ long; tail of female bluntly pointed; male 6.5 to 7.5 mm. long, female 8 to 10 mm. long.....*Ostertagia mentulata*, p. 68
Spicules of male less than 400μ long..... 2
2. Spicules of male 150 to 180μ long; bursa about 300μ wide when both wings are spread out; latero-ventral ray thickest of the rays; stem of dorsal ray 40 to 50μ long; branches 35 to 40μ long; male 6.5 to 7 mm. long. .*Ostertagia trifurcata*, p. 62
Spicules of male over 200μ in length..... 3
3. Stem of dorsal ray of bursa five times as long as its two main branches; spicules 210μ long; male 4.5 to 5 mm. long, female 6 to 7 mm. long. *Ostertagia brigantiaica*, p. 69
Stem of dorsal ray less than three times as long as its two main branches..... 4
4. Bursa over 0.5 mm. in width, when both wings are spread out; dorsal ray over 200μ long..... 5
Bursa less than 0.5 mm. in width, when both wings are spread out; dorsal ray less than 100μ long..... 6
5. Spicules of male 250 to 280μ long, rather delicate in structure, light yellowish-brown; gubernaculum absent; male 10 to 13 mm. long, female 12 to 20 mm. long; eggs large, 160 to 200μ long.....*Ostertagia marshalli*, p. 62
Spicules of male 290 to 320μ long, strongly built, dark yellowish-brown; gubernaculum present, about 120μ long; male 12 to 16 mm. long.
Ostertagia occidentalis, p. 67
6. Main branches of dorsal ray of bursa bifid at the tip, without secondary branches; spicules 220 to 230μ long; gubernaculum about 65μ long; tail of female terminates in a rather acute point without annular striations near the tip; male 6.5 to 7.5 mm. long, female 8.3 to 9.2 mm. long.*Ostertagia ostertagi*, p. 56
Main branches of the dorsal ray with a small, short, secondary branch externally and one internally in the distal portion, the latter near the tip; spicules 280 to 320μ long; gubernaculum about 90μ long; tail of female terminating in a rather blunt rounded point, slightly swollen a short distance from the tip and in this region marked by 3 to 5 annular striations; male 7.5 to 8.5 mm. long, female 9.8 to 12.2 mm. long.....*Ostertagia circumcincta*, p. 59

Ostertagia ostertagi (Stiles, 1892) Ransom, 1907.

(Figs. 38-43.)

- 1890: *Strongylus convolutus* Ostertag, 1890b, pp. 457-460 (not *S. convolutus* Kuhn, 1829).
 1892: *Strongylus ostertagi* Stiles, 1892e, pp. 147-148 (*S. convolutus* Ostertag, 1890 [not Kuhn, 1829] renamed).
 1893: *Strongylus* sp. Harker, 1893, Agric. Students' Gaz., Cirencester, n. s., v. 6 (4), Aug., pp. 94-97, figs. 1-5 (in part, fig. 2 evidently drawn from a male of *O. ostertagi*).
 1899: *Strongylus cervicornis* of Gilruth, 1899a, p. 25 (misidentification).
 1901: *Strongylus harkeri* Stödter, 1901a, pp. 72, 75, 91, pl. 11, figs. 1-5 (in part).
 1907: *Ostertagia ostertagi* (Stiles, 1892) Ransom, 1907k, p. 2.

SPECIFIC DIAGNOSIS.—*Ostertagia* (p. 54): Male 6.5 to 7.5 mm. long. Maximum thickness 115 to 130 μ just in front of bursa. Diameter of head 16 to 18 μ ; diameter of body at level of nerve ring 40 to 45 μ , at base of esophagus 60 to 75 μ . Esophagus 650 to 680 μ in length, surrounded by a nerve ring at a distance of 265 to 280 μ from the anterior end. The excretory pore is situated about 300 μ and the cervical papillæ 340 μ from the anterior end of the body. The esophagus increases very gradually in diameter from 12 or 15 μ anteriorly to 40 or 50 μ at its posterior end. Bursa (figs. 39, 40) comparatively small, not over twice as wide as the maximum thickness of the body when both lobes are spread out. Posterior end of the body truncate, projecting backward between the wings of the bursa, ventrally forming two rounded protuberances separated by a shallow median groove. The paired rays are of nearly equal thickness, except the latero-ventral ray, which is slightly thicker than the others. Measured on the periphery of the bursa, the distance between the anterior end of the bursa and the tips of the ventral rays (*v. v.*, *l. v.*, figs. 39, 40) is about equal to that between the latter and the tip of the externo-dorsal ray (*e. d.*, figs. 39, 40). The tips of the medio-lateral (*m. l.*, figs. 39, 40) and postero-lateral rays, like those of the ventral rays, are very close together. The dorsal ray (*d.*, figs. 39, 40) is about 50 to 60 μ in length, bifurcated 35 to 45 μ from its root, the two branches being straight and slender, diverging somewhat, and each dividing into two very short branches at the tip. The spicules (fig. 41, *sp.*, fig. 39) measure 220 to 230 μ in length. Two slender processes barbed at the tip come off from the inner side of each spicule in its posterior half. When the spicule is retracted, these processes lie close to the body of the spicule, but when the spicule is protruded, their tips spring away from the body of the spicule, one in the dorsal and the other in the ventral direction, giving the end of the spicule in a lateral view a three-forked appearance, the body of the spicule truncated at the distal end forming the thick middle branch, and the barbed processes forming the more slender dorsal and ventral branches of the fork. The gubernaculum is elongated, its body oval, rounded anteriorly, and drawn into a slender process posteriorly. The body of the gubernaculum is about 14 μ wide and 40 μ long, exclusive of the posterior process, which is about 25 μ in length. Prominent short strands of muscle extend between the gubernaculum and the dorsal surface of the body, arranged in two groups side by side. These muscle groups measure about 70 μ in length (antero-posteriorly) and 18 μ in transverse thickness.

Female 8.3 to 9.2 mm. long by 120 to 160 μ in thickness in the region of the vulva. The head measures 18 to 20 μ in diameter; at the nerve ring the body is 40 to 45 μ in thickness, at the base of the esophagus 65 to 85 μ , and at the anus 40 to 50 μ . The esophagus is similar in size to that of the male, and is surrounded by a nerve ring 260 to 280 μ from the anterior end. The vulva (*vul.*, fig. 42) is a transverse slit covered by a prominent cuticular flap (*lab.*, fig. 42), and is situated 1.3 to 1.5 mm. from the posterior end of the body. The tail (fig. 43) tapers gradually and ends in a slender rounded tip. The anus (*an.*, fig. 43) is situated 100 to 140 μ from the tip of the tail. The muscular portions of the ovijectors (*ovij.* 1-2, fig. 43) form an elongated barrel-

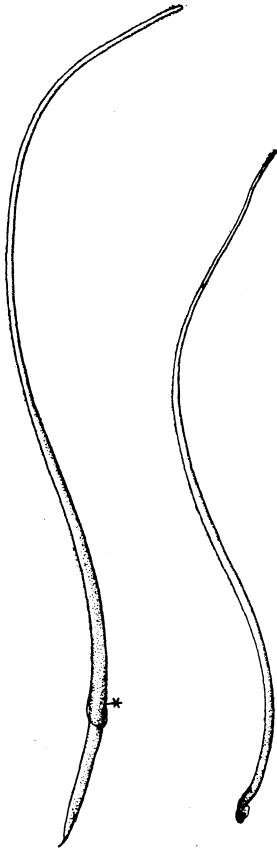


FIG. 38.—*Ostertagia ostertagi*. Male at right, female at left. *Vulva. $\times 15$. (Original.)

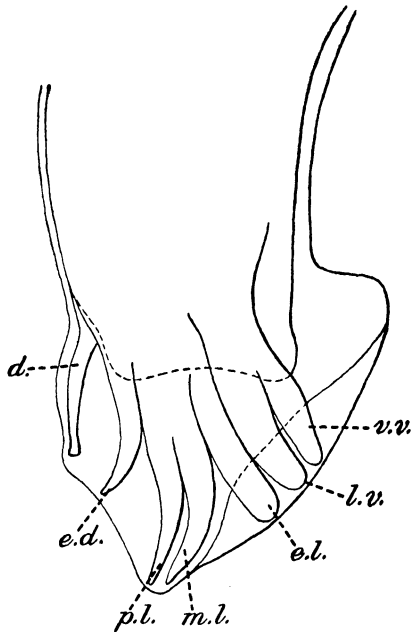


FIG. 40.—*Ostertagia ostertagi*. Bursa of male, viewed from right side. *d.*, dorsal ray; *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *v. v.*, ventro-ventral ray. $\times 300$. (Original.)

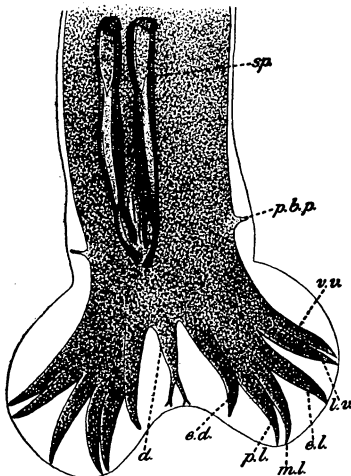


FIG. 39.—*Ostertagia ostertagi*. Posterior end of body of male with bursa spread out. *d.*, dorsal ray; *e. d.*, externo-dorsal ray; *p. l.*, postero-lateral ray; *m. l.*, medio-lateral ray; *e. l.*, externo-lateral ray; *l. v.*, latero-ventral ray; *v. v.*, ventro-ventral ray; *p. b. p.*, pre-bursal papilla; *sp.*, spicules. $\times 150$. (After Railliet, 1893a, fig. 303.)



FIG. 41.—*Ostertagia ostertagi*. Spicule of male, lateral view. $\times 300$. (Original.)

shaped structure measuring 200 to 260 μ long, including the sphincters, and 60 to 80 μ in diameter. The eggs measure from 65 by 30 μ to 80 by 40 μ in diameter.

Hosts.—*Cattle (*Bos taurus*); *bharal (*Ovis nahura*); ?sheep (*Ovis aries*).

LOCATION.—Small nodules in the wall of the fourth stomach and also free in the cavity of the fourth stomach.

LOCALITIES COLLECTED.—Europe, United States, ?Australia, and New Zealand.

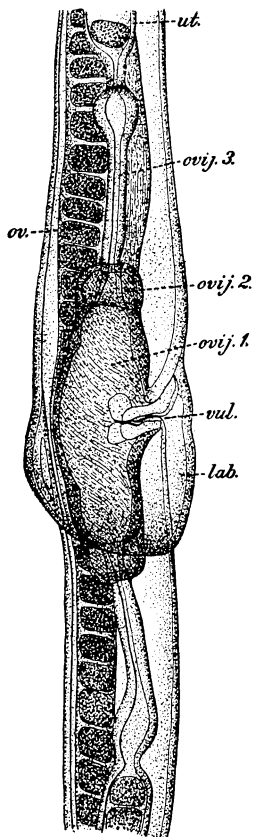


FIG. 42.—*Ostertagia ostertagi*. Body of female in region of vulva, viewed from right side. lab., cuticular flap covering vulva; ov., ovary; ovij. 1, terminal portion of ovijector; ovij. 2, sphincter of ovijector; ovij. 3, nonmuscular portion of ovijector; ut., uterus; vul., vulva. $\times 150$. (Original.)

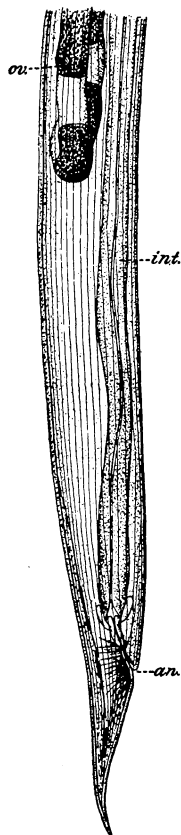


FIG. 43.—*Ostertagia ostertagi*. Posterior end of body of female viewed from right side. an., anus; int., intestine; ov., ovary. $\times 150$. (Original.)

This species has been frequently reported by various authors as a parasite of sheep, but in most instances such reports have evidently resulted from a confusion with *Ostertagia circumcincta*. Among hundreds of specimens of species of *Ostertagia* from domestic sheep, mostly collected in this country, which I have examined, I have failed to find *O. ostertagi*. I have, however, found it once in a blue

wild sheep or bharal which died at the National Zoological Park, Washington, D. C.

According to Stadelmann (1891a), the small nodules in which this species is found vary in size from that of a pin head to that of a pea. The presence of *O. ostertagi* in young cattle is commonly associated with an anemic condition of the animals. The parasites not only apparently suck blood, but set up a catarrhal inflammation in spots on the stomach wall, where the nodules are numerous. The development of the parasite is evidently direct, without intermediate host. Following infection, the larvæ penetrate beneath the epithelium of the stomach and there develop to maturity, undergoing two molts in the process of growth.

***Ostertagia circumcincta* (Stadelmann, 1894) Ransom, 1907.**

(Figs. 44-49.)

1893: *Strongylus vicarius* Stadelmann, 1893a, pp. 219-220 (possibly identical with *O. circumcincta*).

1894: *Strongylus circumcinctus* Stadelmann, 1894a, pp. 142-146, figs. 1-2.

1897: *Strongylus cervicornis* McFadyean, 1897c, pp. 48-63, fig. 1, pl. 1, figs. 2-10.

1897: *Strongylus instabilis* Railliet of Julien, 1897e, p. 544, fig. 3a-c (misdetermination).

1907: *Ostertagia circumcincta* (Stadelmann, 1894) Ransom, 1907k, p. 2.

SPECIFIC DIAGNOSIS.—*Ostertagia* (p. 54): Lips or circumoral papillæ indistinct. Head about 18μ in diameter. Cervical papillæ 210 to 350μ from anterior end. Cuticle with about 30 longitudinal ridges. Esophagus 500 to 640μ in length by about 12μ in diameter at the beginning and 40 to 50μ at the posterior end, surrounded by a nerve ring a little in front of the middle. Excretory pore in the neighborhood of the nerve ring.

Male 7.5 to 8.5 mm. long by 100 to 130μ in maximum thickness. Bursa (figs. 45, 46) about three times as wide as the maximum thickness of the body when both wings are spread out. The latero-ventral (*l. v.*, figs. 45, 46), externo-lateral (*e. l.*, figs. 45, 46), and medio-lateral (*m. l.*, figs. 45, 46) rays are of about equal thickness, the externo-lateral ray being usually the thickest of the three and all are thicker than the other rays. The tips of the externo-lateral, medio-lateral, postero-lateral (*p. l.*, figs. 45, 46), and externo-dorsal (*e. d.*, figs. 45, 46) rays are separated successively by nearly equal intervals. The dorsal ray (*d.*, fig. 46) has a stem 50 to 60μ long with branches (*t. d.*, fig. 45) about 40μ in length, each with two short side branches, one internally near the tip and the other externally at a greater distance from the tip. Spicules (fig. 47) 280 to 320μ long, divided distally into a slender tapering pointed inner process, and a thicker, slightly longer outer process, slightly curved ventrally near the end and truncated at the tip. Gubernaculum or accessory piece (*gub.*, fig. 47) with lozenge-shaped body rounded at the angles, and slender posterior process; total length about 90μ , of which the posterior process makes up about two-thirds; maximum width about 30μ .

Female 9.8 to 12.2 mm. long by 100 to 160μ in maximum thickness in the region of the vulva. Vulva situated 1.9 to 2.3 mm. from the posterior end of the body, transversely elongated, crescentic, may be naked, but is usually covered by a backward projecting flap. Anus (*an.*, fig. 48) 130 to 160μ from the tip of the tail. Diameter of the body at the anus 35 to 55μ . Tail gradually attenuated and rounded at the tip. A short distance in front of the tip the tail is slightly swollen and in this region is marked by 3 to 5 annular striations (fig. 49). Combined length of the muscular por-

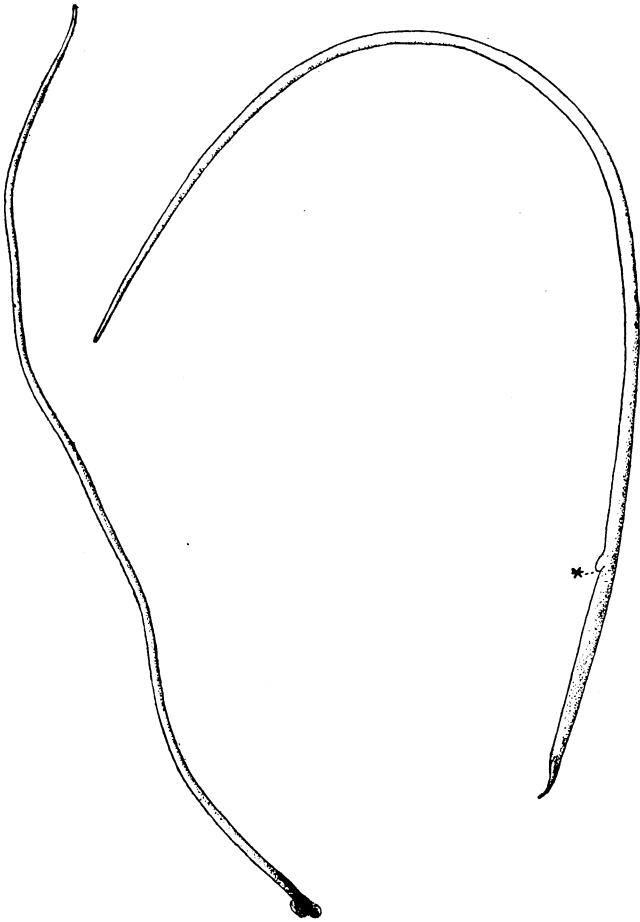


FIG. 44.—*Ostertagia circumcincta*. Male at left, female at right. *Vulva. $\times 15$. (Original.)

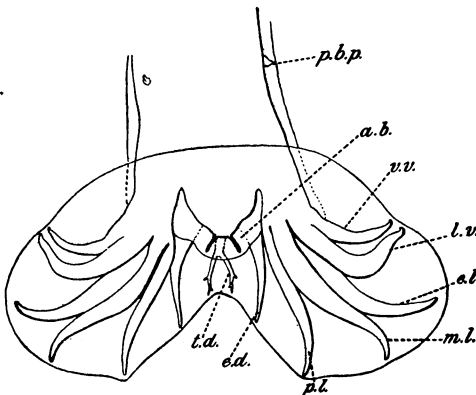


FIG. 45.—*Ostertagia circumcincta*. Bursa of male spread out. Ventral view. a. b., accessory bursal membrane; e. d., externo-dorsal ray; e. l., externo-lateral ray; l. v., latero-ventral ray; m. l., medio-lateral ray; p. b. p., pre-bursal papilla; p. l., postero-lateral ray; t. d., terminal branch of dorsal ray; v. v., ventro-ventral ray. $\times 150$. (Original.)

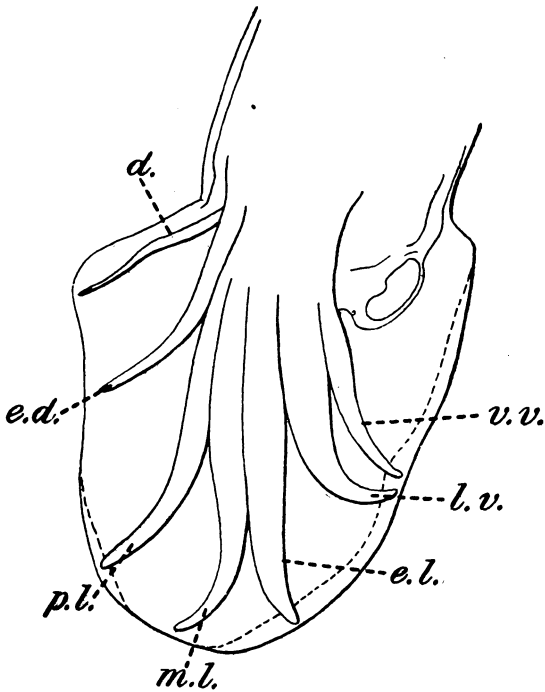


FIG. 46.—*Ostertagia circumcincta*. Bursa of male, viewed from right side. *d.*, dorsal ray; *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *v. v.*, ventro-ventral ray. $\times 300$. (Original.)

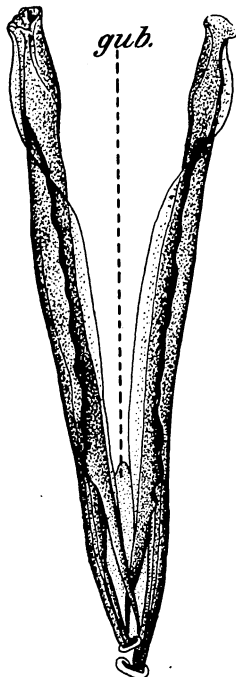


FIG. 47.—*Ostertagia circumcincta*. Spicules and gubernaculum of male. Ventral view. *gub.*, gubernaculum. $\times 300$. (Original.)

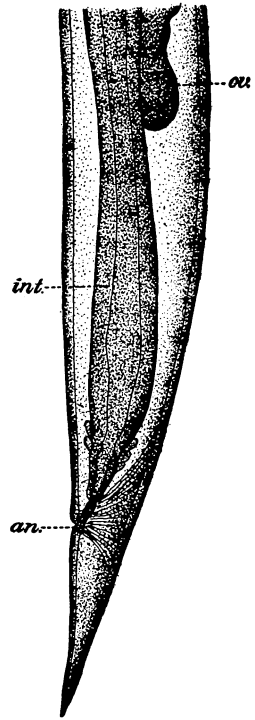


FIG. 48.—*Ostertagia circumcincta*. Posterior end of body of female, viewed from left side. *an.*, anus *int.*, intestine; *ov.*, ovary. $\times 150$. (Original.)



FIG. 49.—*Ostertagia circumcincta*. Tip of tail of female. $\times 400$. (Original.)

tions of the ovijectors including the sphincters 330 to 560 μ . Eggs 75 to 100 μ long by 35 to 50 μ wide.

HOSTS.—*Sheep (*Ovis aries*); *goat (*Capra hircus*); *prong-horned antelope (*Antilocapra americana*); *Newfoundland caribou (*Rangifer terrænovæ*).

LOCATION.—Fourth stomach and small intestine.

LOCALITIES COLLECTED.—Europe, United States, New Zealand, Australia.

The form from the fourth stomach of sheep which Stadelmann (1893a) referred to as *Strongylus vicarius* may possibly be of the same species as his *S. circumcinctus*. The identity of *S. vicarius* will probably, however, always remain doubtful, as type specimens apparently were not preserved, and as it is impossible to determine specimens definitely as *S. vicarius* upon the basis of Stadelmann's description.

***Ostertagia trifurcata* Ransom, 1907.**

(Figs. 50-54.)

1907: *Ostertagia trifurcata* Ransom, 1907k, p. 2.

SPECIFIC DIAGNOSIS.—*Ostertagia* (p. 54): *Male* 6.5 to 7 mm. long by 80 to 100 μ in maximum thickness just in front of bursa. Longitudinal ridges of the cuticle frequently exhibit a very finely beaded appearance. Head about 15 μ in diameter. Esophagus 460 to 480 μ in length by 10 μ in diameter anteriorly gradually increasing in thickness posteriorly, and reaching a maximum diameter of about 40 μ . Nerve ring about 230 μ from the anterior end; cervical papillæ 300 μ ; and excretory pore 290 μ . Bursa (figs. 51, 52) about 300 μ in width when both wings are spread out. The latero-ventral (*l. v.*, figs. 51, 52), externo-lateral (*e. l.*, figs. 51, 52), and medio-lateral (*m. l.*, figs. 51, 52), rays are thicker than the other rays and are about equal in thickness, the latero-ventral ray, however, being slightly the thickest. The tips of the externo-dorsal (*e. d.*, figs. 51, 52), postero-lateral (*p. l.*, figs. 51, 52), and medio-lateral rays are separated successively by nearly equal intervals, about twice as great as the interval between the tips of the medio-lateral and externo-lateral rays. The stem of the dorsal ray measures 40 to 50 μ in length; its branches (*t. d.*, fig. 51) 35 to 40 μ . Each branch near its middle has a short branch on its outer side, and near the tip a short branch on the inner side as in *O. circumcincta*. Spicules (figs. 53, 54) 150 to 180 μ long, divided distally into three processes, one long, thick, and truncated at the end, and two considerably shorter, thinner, tapering, and sharply pointed. Gubernaculum (*gub.*, figs. 53, 54) 70 to 90 μ long by 10 to 15 μ in width anteriorly and drawn out into a slender process posteriorly.

Female unknown.

HOSTS.—*Sheep (*Ovis aries*); *goat (*Capra hircus*).

LOCATION.—Fourth stomach, more rarely small intestine.

LOCALITIES COLLECTED.—United States.

TYPE SPECIMENS.—Bureau of Animal Industry Helminthological Collection, No. 4252, collected November 27, 1905, at Bethesda, Md., by Dr. E. C. Stevenson from the fourth stomach of a sheep.

This species has been found several times in small numbers in sheep and goats, always associated with *O. circumcincta*.

***Ostertagia marshalli* Ransom, 1907.**

(Figs. 55-58.)

1904: *Hæmonchus* sp. Marshall, 1904a, p. 182.

1907: *Ostertagia marshalli* Ransom, 1907k, p. 3.

SPECIFIC DIAGNOSIS.—*Ostertagia* (p. 54): *Male* 10 to 13 mm. long by 165 to 200 μ in maximum thickness at base of bursa. Head 15 to 20 μ in thickness; diameter of body at base of esophagus 70 to 80 μ . Cervical papillæ 340 to 415 μ from anterior end of body.

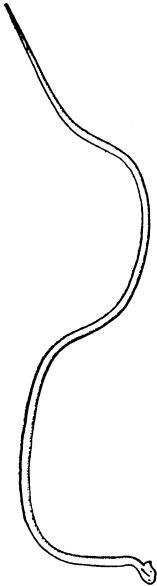


FIG. 50.—*Ostertagia trifurcata*. Male. $\times 15$. (Original.)

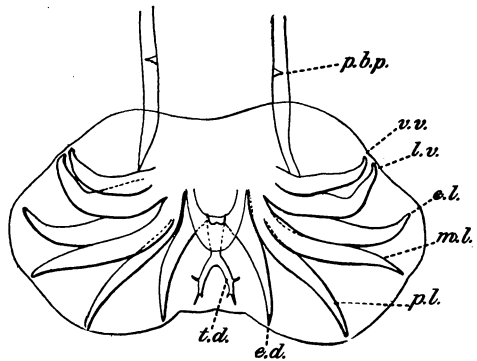


FIG. 51.—*Ostertagia trifurcata*. Posterior end of body of male with bursa spread out. Ventral view. *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. b. p.*, pre-bursal papilla; *p. l.*, postero-lateral ray; *t. d.*, terminal branch of dorsal ray; *v. v.*, ventro-ventral ray. $\times 150$. (Original.)

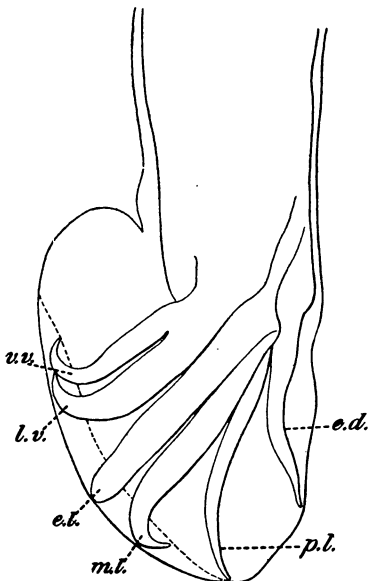


FIG. 52.—*Ostertagia trifurcata*. Posterior end of body of male, viewed from left side. *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *v. v.*, ventro-ventral ray. $\times 300$. (Original.)

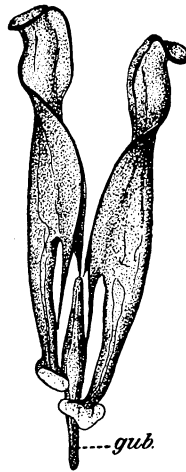


FIG. 53.—*Ostertagia trifurcata*. Spicules and gubernaculum. Ventral view. *gub.*, gubernaculum. $\times 300$. (Original.)



FIG. 54.—*Ostertagia trifurcata*. Spicule and gubernaculum. Lateral view. *gub.*, gubernaculum. $\times 300$. (Original.)

64 NEMATODES PARASITIC IN ALIMENTARY TRACT OF RUMINANTS.

Esophagus 725 to 850 μ long by 10 to 15 μ in diameter anteriorly, increasing to a maximum of 50 to 60 μ at its posterior end, the increase being very slight and gradual until the nerve ring is passed, then there is a sudden increase, then a gradual increase again until

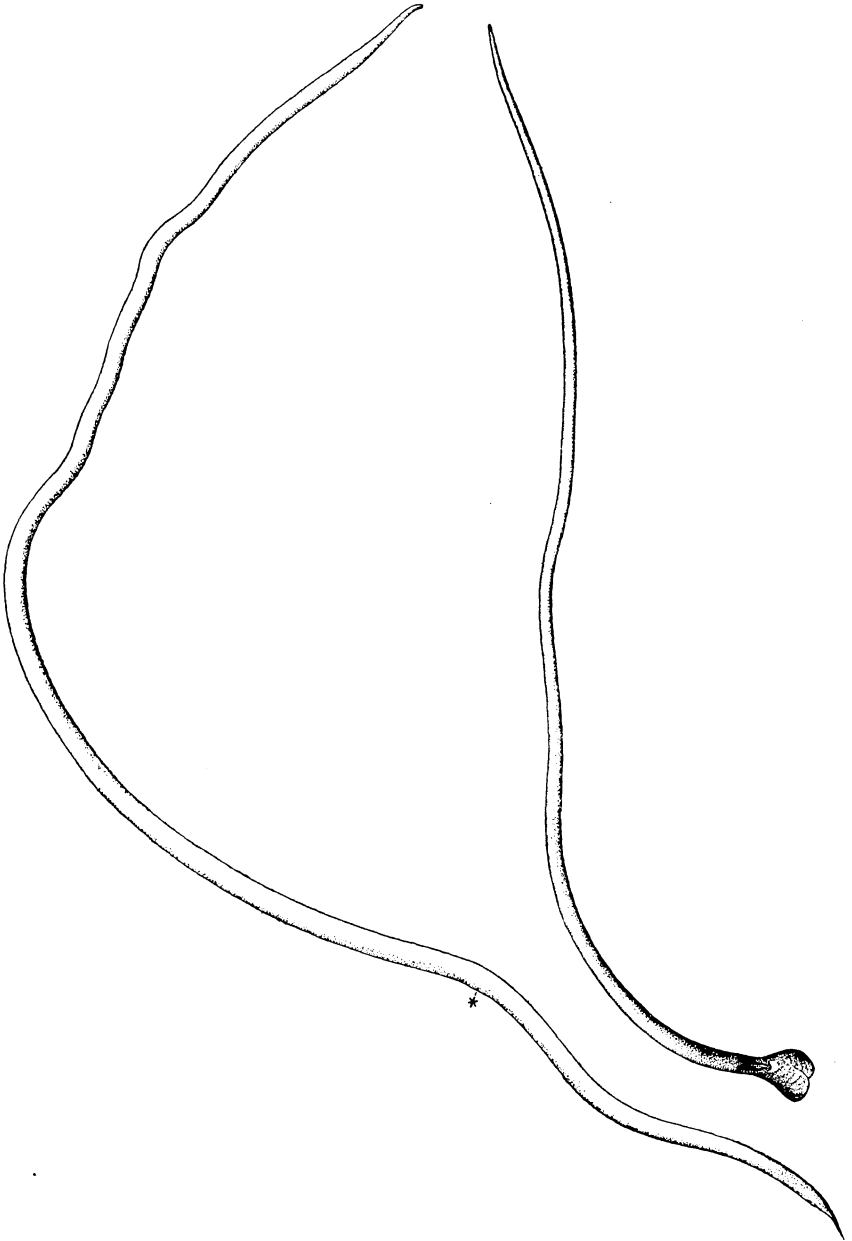


FIG. 55.—*Ostertagia marshalli*. Male at right, female at left. *Vulva. $\times 15$. (Original.)

the end is reached. Nerve ring at about one-third the length of the esophagus from its anterior end. Bursa (fig. 56) 550 to 690 μ in width when both wings are spread out. Dorsal ray (*d.*, fig. 56) slender, 280 to 400 μ long, bifurcated 200 to 280 μ from its base.

Each branch is cleft at the end, near which is also a short lateral branch on the outer side. In order of thickness the paired rays rank as follows: Latero-ventral (*l. v.*, fig. 56), externo-lateral (*e. l.*, fig. 56), and medio-lateral (*m. l.*, fig. 56) of about the same maximum thickness, then the postero-lateral (*p. l.*, fig. 56), and finally the externo-dorsal (*e. d.*, fig. 56), and ventro-ventral ray (*v. v.*, fig. 56), the last being the shortest as well as usually the most slender. The tips of the externo-dorsal, postero-lateral, and medio-lateral rays are separated successively by nearly equal intervals, about half as great as the interval between the tips of the medio-lateral and externo-lateral rays. The latter interval is about equal to that between the tips of the externo-lateral and latero-ventral rays. The tips of the externo-dorsal, medio-lateral, and externo-lateral rays usually fall a little short of the margin of the bursa. Accessory bursal membrane (*a. b.*, fig. 56) 65 to 75 μ long by 70 μ wide; its supporting rays about 65 μ long. Spicules (fig. 57) 250 to 280 μ long, light yellowish-brown in color and rather delicate in struc-

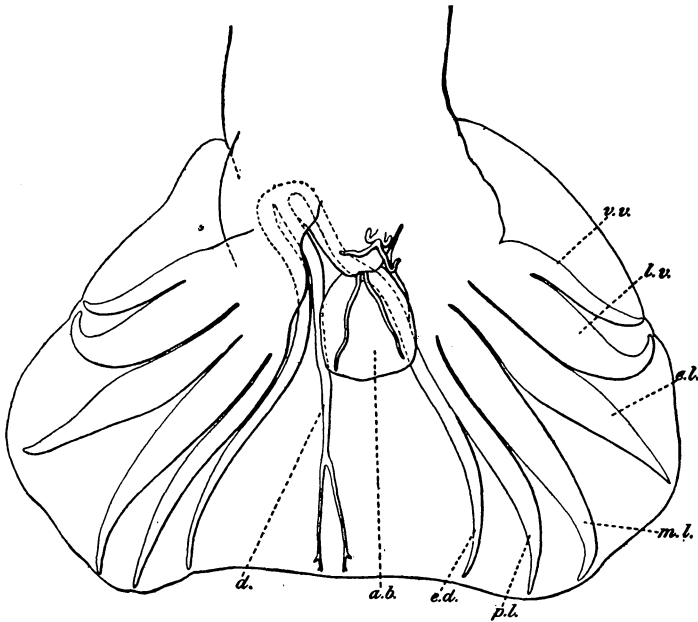


FIG. 56.—*Ostertagia marshalli*. Bursa of male spread out. *a. b.*, accessory bursal membrane; *d.*, dorsal ray; *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *v. v.*, ventro-ventral ray. $\times 150$. (Original.)

ture, split lengthwise in the posterior fourth to form three terminal processes, two ventral and one dorsal. The last is shorter, broader, thinner, and less conspicuous than the other two, both of which are slender. The outer ventral branch is the longest and terminates in an acute point. The end of the inner branch is conical, with a short, blunt, recurved barb. A gubernaculum is absent.

Female 12 to 20 mm. long by 200 to 260 μ in maximum width in the region of the vulva. Head 15 to 20 μ broad; diameter of body at base of esophagus 85 to 100 μ , at anus 40 to 60 μ . Cervical papillæ 325 to 400 μ from anterior end of body. Esophagus 700 to 900 μ long, similar in shape and thickness to that of the male. Nerve ring about one-third the length of the esophagus from its anterior end. Anus (*an.*, fig. 58) 200 to 300 μ from the tip of the tail. The tail is slender, gradually attenuated and rounded at the tip. The vulva is a transverse slit about 125 μ long, situated 2.5 to 5 mm. from the tip of the tail, naked or covered by a backward projecting flap. Combined length

of muscular portions of ovijectors, including the sphincters, about 575μ . Eggs large, 160 to 200μ long by 75 to 100μ broad.

Host.—*Sheep (*Ovis aries*).

LOCATION.—Fourth stomach, more rarely small intestine.

LOCALITY COLLECTED.—Montana.

TYPE SPECIMENS.—Bureau of Animal Industry Helminthological Collection No.

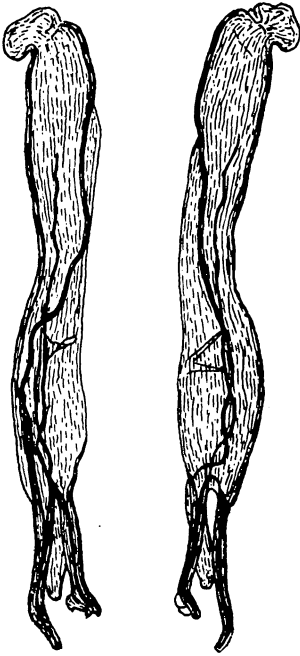


FIG. 57.—*Ostertagia marshalli*. Spicules of male. $\times 300$. (Original.)

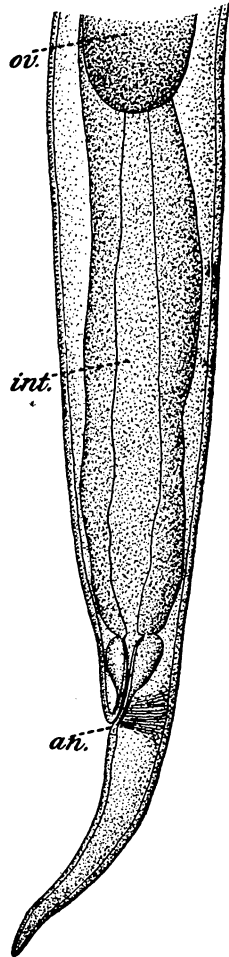


FIG. 58.—*Ostertagia marshalli*. Posterior end of body of female, viewed from left side. an., anus; int., intestine; ov., ovary. $\times 150$. (Original.)

4689, collected February 12, 1907, at Washington, D. C., by Dr. E. C. Stevenson from a sheep received from Montana.

This species was first collected by Dr. H. T. Marshall and Prof. V. K. Chesnut in Montana and has so far been found only in that State or in sheep which have been brought from there. At the

present time, therefore, it seems to be confined to the Rocky Mountain region of the United States.

***Ostertagia occidentalis* Ransom, 1907.**

(Figs. 50-61.)

1907: *Ostertagia occidentalis* Ransom, 1907k, p. 3.

SPECIFIC DIAGNOSIS.—*Ostertagia* (p. 54): *Male* 12 to 16 mm. long by 200 to 240 μ in maximum thickness at base of bursa. Head 15 to 18 μ in diameter; diameter of body at base of esophagus 95 to 100 μ . Esophagus 820 to 980 μ long by 12 to 14 μ in diameter anteriorly and 50 to 65 μ in diameter at the posterior end. It increases slightly and gradually in diameter until it passes the nerve ring, and there undergoes a sudden increase, after which it again increases gradually toward the posterior end. Nerve ring 280 to 300 μ and cervical papillæ 350 to 400 μ from the anterior end of the body. Bursa (fig. 60) 650 to 740 μ wide when spread out. Dorsal ray (*d.*, fig. 60), 280 to 300 μ long, bifurcated at a distance of about 200 μ from its origin. Each branch is cleft at its extremity and bears a short lateral branch on its outer side near the end. In order of thickness the paired rays usually rank as follows: Thickest, externo-lateral (*e. l.*, fig. 60), then latero-ventral (*l. v.*, fig. 60), and medio-lateral (*m. l.*, fig. 60), of very nearly the same size, then postero-lateral (*p. l.*, fig. 60), externo-dorsal (*e. d.*, fig. 60), and ventro-ventral (*v. v.*, fig. 60). The tip of the externo-lateral ray is almost equidistant between the tips of the latero-ventral and medio-lateral rays, the intervals between these three being more than twice as great as the nearly equal intervals which separate successively the tips of the externo-dorsal, postero-lateral, and medio-lateral rays. The tips of the externo-dorsal and externo-lateral rays fall some distance short of the margin of the bursa. The accessory bursal membrane (*a. b.*, fig. 60) is about 60 μ long by 50 μ wide, with supporting rays about 40 μ long. The spicules (fig. 61), 290 to 320 μ long, are strongly built, dark yellowish-brown in color, and very prominent in appearance. They are divided lengthwise, beginning a short distance posterior of the middle, into three terminal processes, two ventral and one dorsal. The outer ventral process is the longest of the three, obliquely truncated at the end, the inner process the shortest and slenderest, terminating in a short mucronate point. The dorsal process is intermediate in length and is the thickest of the three, being slightly thicker than the outer process. It terminates in a rounded conical tip set off from the rest of the process by a transverse ridge on the dorsal side. Gubernaculum (*gub.*, fig. 61), about 120 μ long by 15 to 20 μ wide anteriorly, more slender posteriorly, very inconspicuous.

Female unknown.

Host.—*Sheep (*Ovis aries*).

Location.—Fourth stomach, more rarely small intestine.

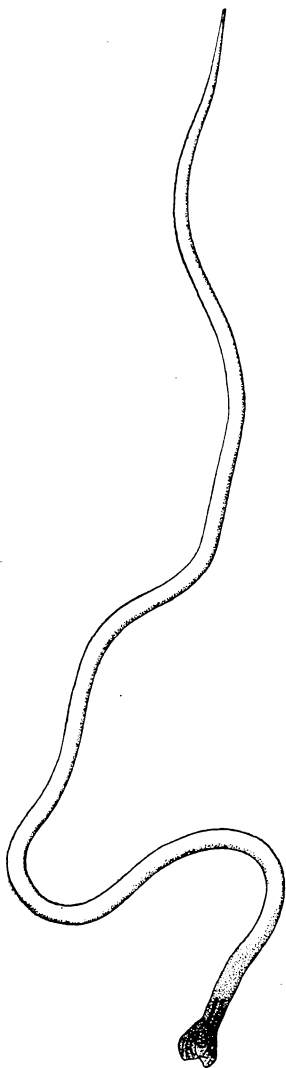


FIG. 59.—*Ostertagia occidentalis*.
Male. $\times 15$. (Original.)

LOCALITY COLLECTED.—Montana.

TYPE SPECIMENS.—Bureau of Animal Industry Helminthological Collection No. 4691, collected February 12, 1907, at Washington, D. C., by Dr. E. C. Stevenson, from a sheep received from Montana.

This species, like *Ostertagia marshalli*, appears to be confined to the Rocky Mountain region. It has been collected several times from Montana sheep, always associated with *O. marshalli*.

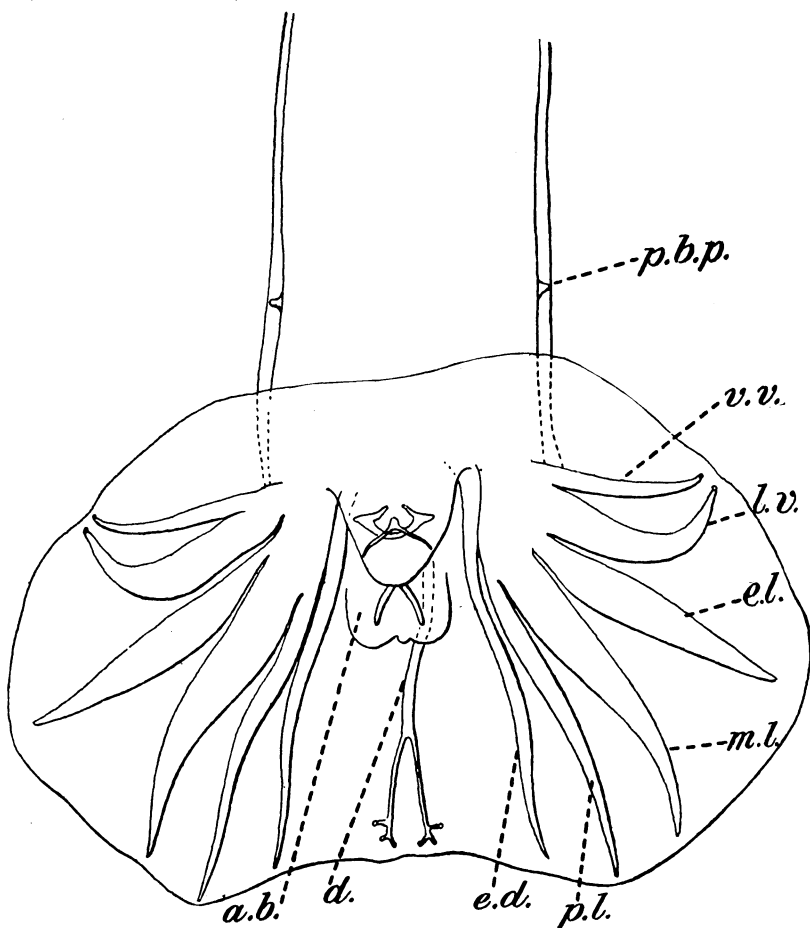


FIG. 60.—*Ostertagia occidentalis*. Posterior end of body of male, with bursa spread out. Ventral view. *a. b.*, accessory bursal membrane; *d.*, dorsal ray; *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. b. p.*, pre-bursal papilla; *p. l.*, postero-lateral ray; *v. v.*, ventro-ventral ray. $\times 150$. (Original.)

Ostertagia mentulata Railliet and Henry, 1909.

(Figs. 62-63.)

1909: *Ostertagia mentulata* Railliet and Henry, 1909a, p. 87 (from *Camelus dromedarius*, India).

SPECIFIC DIAGNOSIS.—*Ostertagia* (p. 54): Cuticle marked with about 30 longitudinal lines. Cervical papillæ 350μ (in female) to 450μ (in male) from the anterior end. Esophagus 750μ (in female) to 1 mm. (in male) in length.

Male 6.5 to 7.5 long. Membranous wings present along the lateral lines in the posterior portion of the body. Spicules long (700μ), with pincer-like termination 90μ long. One of the branches of the pincer is a little longer than the other, ending in a hammer-shaped hook.

Female 8 to 10 mm. long. Vulva in the posterior fifth of the body. Tail bluntly pointed.

HOST.—*Arabian camel (*Camelus dromedarius*).

LOCATION.—Fourth stomach.

LOCALITIES COLLECTED.—India, United States.

The foregoing diagnosis is taken from the brief description given by Railliet and Henry (1909a). The Bureau of Animal Industry collection contains specimens apparently belonging to this species collected from the stomach of a dromedary which died at the National Zoological Park, Washington, D. C. The accompanying drawings were made from these specimens.

Ostertagia brigantiaca Blanchard, 1909.

1909: *Ostertagia brigantiaca* Blanchard in Railliet and Henry, 1909a, p. 87 (from Chamois, France).

SPECIFIC DIAGNOSIS.—*Ostertagia* (p. 54): Male 4.25 to 5 mm. long, Spicules 210μ long. Bursa unilobed, with posterior ray as long as the bursa. Trunk of the posterior ray five times the length of its branches.

Female 6 to 7 mm. long.

HOST.—Chamois (*Rupicapra rupicapra*).

LOCATION.—Duodenum.

LOCALITY COLLECTED.—France.

The foregoing description is taken from the brief description given by Railliet and Henry (1909a).

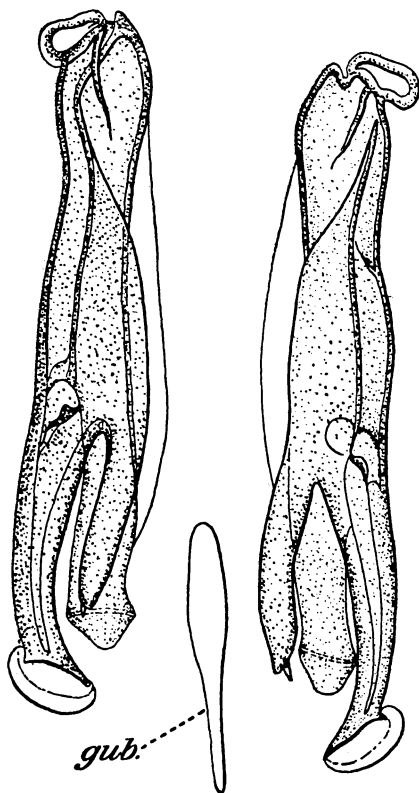


FIG. 61.—*Ostertagia occidentalis*. Spicules and gubernaculum of male. Ventral view. *gub.*, gubernaculum. $\times 300$. (Original.)

Genus COOPERIA Ransom, 1907.

1907: *Cooperia* Ransom, 1907k, pp. 3–4.

GENERIC DIAGNOSIS.—*Metastrongylinae* (p. 47): Head rounded, relatively thick, 25μ or more in diameter, without well marked lips or papillae. Cuticle of head region transversely striated, and often dilated, giving the head a swollen or bulbous appearance. Cuticle of remainder of body with 14 to 16 longitudinal lines or ridges. From a surface view each longitudinal line or ridge appears to be made up of a row of small punctations standing close together, which resemble striations perpendicular to the surface of the body when the longitudinal line or ridge is viewed from the side. Cervical

papillæ absent. Mouth cavity small, indefinite. Bursa of male with two lateral lobes and a small median lobe. Vento-ventral ray short and slender, curving forward. Distal portion of latero-ventral ray curves forward, while the distal portion

of the externo-lateral ray turns backward so that the tips of these two rays are far apart. The other lateral rays and the externo-dorsal ray also turn backward and their tips are near the posterior border of the bursa, separated by short intervals. The unpaired

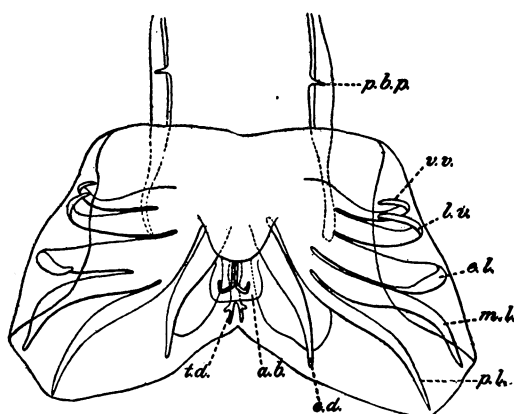


FIG. 62.—*Ostertagia mentulata*. Posterior end of body of male, with bursa partially spread out. Ventral view. *a. b.*, accessory bursal membrane; *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. b. p.*, pre-bursal papilla; *p. l.*, postero-lateral ray; *t. d.*, terminal branch of dorsal ray; *v. v.*, vento-ventral ray. $\times 150$. (Original.)

dorsal ray is divided into two prominent branches which may be parallel or curved so as to form together a lyre-shaped or horseshoe-shaped structure. Each branch may or not be cleft at the end. From each main branch, usually near its junction with the stem of the dorsal ray, a short branch extends ventrally into a vesicular swelling on the inner surface of the bursa. Spicules short. Gubernaculum or accessory piece absent. Prebursal papillæ absent. Vulva in the posterior fourth of the body, elongated transversely or longitudinally. Ovijectors well developed. Eggs oval with thin shells measuring 60 to 80μ in length.

TYPE SPECIES.—*Cooperia curticei* (Railliet, 1893) Railliet and Henry, 1909.

Four species of *Cooperia* occur in ruminants, and all of these have been found in America.

KEY TO SPECIES OF COOPERIA.

1. Spicules of male less than 200μ in length 2
 Spicules more than 200μ in length..... 3
2. Branches of the dorsal ray of bursa curved to form a lyre-shaped structure; spicules 135 to 145μ long; vulva of female a transverse slit; male 4.6 to 5.4 mm. long, female 5.8 to 6.2 mm. long... *Cooperia curticei*, p. 71

Branches of the dorsal ray of bursa nearly straight, almost parallel; spicules 120 to 150μ long; vulva of female crescentic in shape, elongated longitudinally; male 4.7 to 5.9 mm. long, female 5.7 to 7.5 mm. long... *Cooperia punctata*, p. 74



FIG. 63.—*Ostertagia mentulata*. Spicules and gubernaculum of male. Ventral view. *gu. b.*, gubernaculum. $\times 300$. (Original.)

3. Main branches of the dorsal ray of the bursa rather widely divergent, forming a U-shaped arch with cleft tips; spicules 240 to 300 μ long, gradually reduced in size posteriorly; terminal portion of tail of female marked with annular striations; body much swollen in region of vulva; combined length of muscular portions of ovijectors about 700 μ ; male 5.5 to 9 mm. long, female 6 to 8 mm. long.

Cooperia oncophora, p. 77

Main branches of the dorsal ray of the bursa rather close together, parallel, with uncleft tips; spicules 240 to 300 μ long with a prominently projecting corrugated edge in the middle third; terminal portion of very sharply pointed tail of female not marked with annular striations; combined length of muscular portions of ovijectors about 300 μ ; male about 7 mm. long, female 7.5 to 9 mm. long.....*Cooperia pectinata*, p. 81

Cooperia curticei (Railliet, 1893) Railliet and Henry, 1909.

(Figs. 64-71.)

1890: *Strongylus ventricosus* Rudolphi of Curtice, 1890c, pp. 149-150, pl. 20, figs. 1-9 (in part).

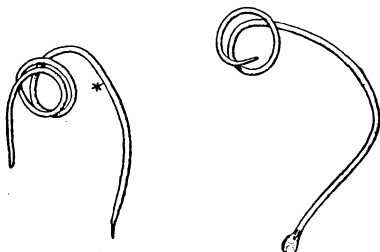


FIG. 64.—*Cooperia curticei*. Male at right, female at left. *Vulva. $\times 15$. (Original.)

1892: *Strongylus curticii* Giles, 1892d, p. 49 (= *S. ventricosus* Rud. of Curtice, 1890, renamed).

1893: *Strongylus curticei* Railliet, 1893a, p. 442 (emendation of *S. curticii*).

1907: *Cooperia curticii* (Giles) Ransom, 1907k, pp. 3-4.

1909: *Cooperia curticei* (Railliet) Railliet and Henry, 1909a, p. 87.

SPECIFIC DIAGNOSIS.—*Cooperia* (p. 69): Anterior end of body usually coiled spirally (fig. 64). Head 28 to 50 μ in diameter, varying according to the degree of expansion of the cuticle. Esophagus 250 to 275 μ long in the male and 255 to 290 μ long in the female; diameter at the anterior end about 20 μ , soon decreasing to about 15 μ , and then gradually increasing to about 30 to 35 μ at its posterior end. Nerving situated near the beginning of the posterior fourth of the esophagus. Excretory pore opening on the ventral surface of the body 10 to 20 μ behind the posterior end of the esophagus.

Male 4.6 to 5.4 mm. long by 75 to 80 μ in maximum diameter. Bursa (figs. 66, 67) about 300 μ wide when both wings are spread out. The tips of all of the paired rays are very close to the edge of the bursa. The ventro-ventral ray (*v. v.*, figs. 66, 67) is the shortest and most slender of the paired rays. Next in order of thickness is the externo-dorsal (*e. d.*, figs. 66, 67), then the postero-lateral (*p. l.*, figs. 66, 67), medio-lateral (*m. l.*, figs. 66, 67), externo-lateral (*e. l.*, figs. 66, 67), and finally the thickest is the latero-ventral ray (*l. v.*, figs. 66, 67). The externo-lateral is almost but not quite equal in thickness to the latero-ventral ray. The stem of the dorsal ray (*d.*, fig. 66) and its branches are each about 35 μ long. The latter (*t. d.*, figs. 66, 67) are curved so as to form a lyre-shaped structure, each is cleft at the end, and gives off a



FIG. 65.—*Cooperia curticei*. Anterior end of body. Lateral view. $\times 300$. (Original.)

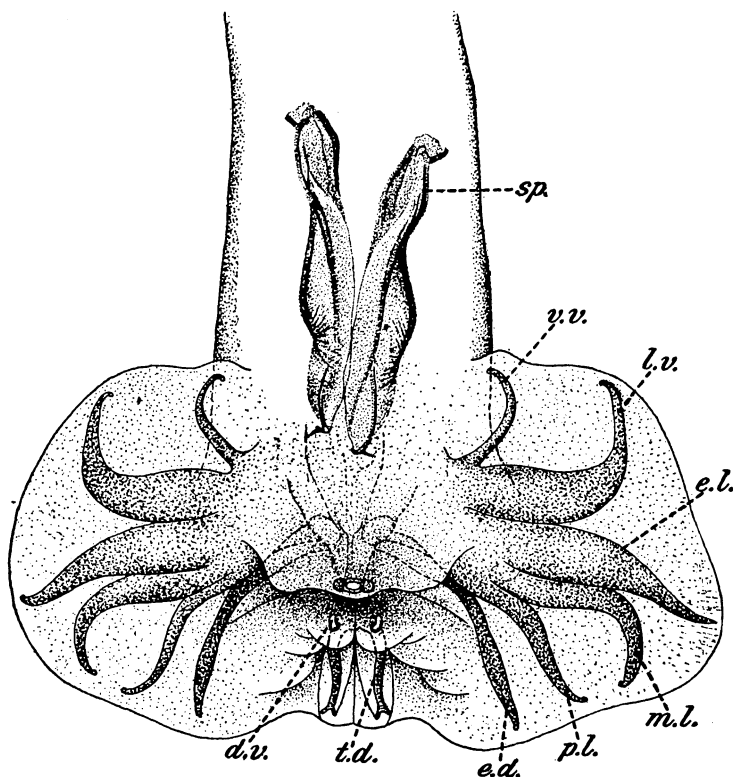


FIG. 66.—*Cooperia curticei*. Posterior end of body of male with bursa spread out. Ventral view. *d. v.*, ventral branch of dorsal ray; *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *sp.*, spicule; *t. d.*, terminal branch of dorsal ray; *v. v.*, ventro-ventral ray. $\times 300$. (Original.)

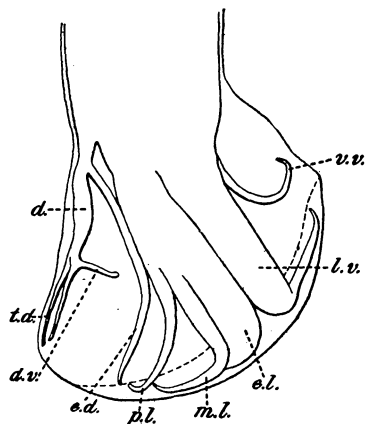


FIG. 67.—*Cooperia curticei*. Bursa of male, viewed from right side. *d.*, dorsal ray; *d. v.*, ventral branch of dorsal ray; *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *t. d.*, terminal branch of dorsal ray; *v. v.*, ventro-ventral ray. $\times 300$. (Original.)

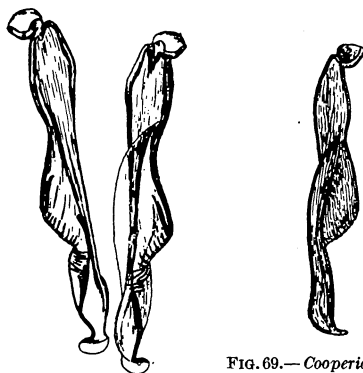


FIG. 68.—*Cooperia curticei*. Spicules of male. Ventral view. $\times 300$. (Original.)

FIG. 69.—*Cooperia curticei*. Spicule of male. Lateral view. $\times 300$. (Original.)

ventral branch (*d. v.*, figs. 66, 67) at its origin. Spicules (figs. 68, 69; *sp.*, fig. 66) 135 to 145 μ long. In the middle region of the spicule the ventral edge forms a thin prominent projection marked on the inner surface with corrugations at right angles to the border.

Female 5.8 to 6.2 mm. long by 75 to 100 μ in maximum thickness. Vulva (*vul.*, fig. 70) a transverse slit about 80 μ in length, surrounded by chitinous lips, and situated 1.25 to 1.4 mm. from the posterior end of the body. Tail (fig. 71) slender, acutely pointed, 110 to 160 μ in length. Combined length of muscular portions of ovjectors

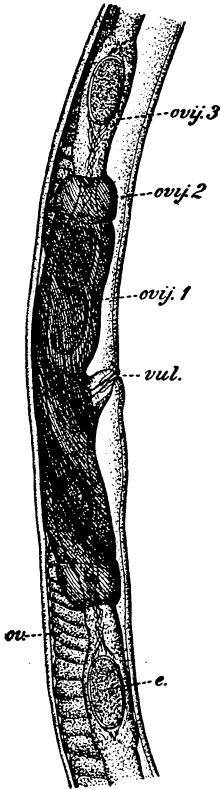


FIG. 70.—*Cooperia curticei*. Body of female in region of vulva viewed from right side. *e.*, egg; *ov.*, ovary; *ovij. 1*, terminal portion of ovjector; *ovij. 2*, sphincter of ovjector; *ovij. 3*, non-muscular portion of ovjector; *vul.*, vulva. $\times 150$. (Original).

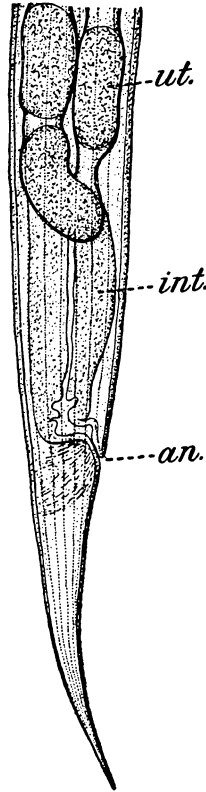


FIG. 71.—*Cooperia curticei*. Posterior end of body of female, viewed from right side. *an.*, anus; *int.*, intestine; *ut.*, uterus. $\times 300$. (Original.)

(*ovij. 1-2*, fig. 70) including the sphincters 375 to 560 μ . The eggs (*e.*, fig. 70) are in the morula stage when laid, measuring 63 to 70 μ in length by 30 to 32 μ in width.

Hosts.—*Sheep (*Ovis aries*); *goat (*Capra hircus*).

LOCATION.—Small intestine, more rarely fourth stomach.

LOCALITIES COLLECTED.—United States and (?) Europe.

Cooperia curticei was originally described by Curtice (1890c) under the name of *Strongylus ventricosus* Rud. Giles (1892d), recognizing certain differences between Curtice's species from sheep and Ru-

dolphi's species from *Cervus elaphus*, renamed the former, *Strongylus curticei*, a name which was corrected to *S. curticei* by Railliet (1893a).

Curtice's description is evidently based on more than one species, as he has shown in his figure 2 a female which is distinctly different from the form shown in his figure 7. The latter, he says, is more characteristic of the species than that of figure 2, but is not quite mature. The fact that he figures eggs in the uterus in figure 7, however, indicates the maturity of the worm from which the drawing was made. I have always found associated with males corresponding to Curtice's figures 1, 8, and 9, mature females corresponding to Curtice's figure 7, and agreeing perfectly with the males as to the head and the markings of the skin, so that there is but little question as to their belonging to the same species. In these females the size of the eggs (63 to 70μ by 30 to 32μ) is much smaller than that given by Curtice (0.13 mm. long by 0.07 mm. wide), who possibly took his measurements from females corresponding to his figure 2. There is a discrepancy between his description of the length of the spicules and the length as indicated in his figure 1. He gives 0.36 mm. as the size of the spicules, but in the figure of a male drawn to a magnification of about 27 times (as may be determined by comparing the length of the line on the plate indicating the natural size of the worm with the length of the magnified worm) the spicules are shown as a little less than 4.5 mm. in length, which divided by 27 gives an actual length of not over 165μ . This is fairly close to the length 135 to 145μ found in specimens which I consider unquestionably of the same species as that figured by Curtice. A further apparent error in Curtice's description and figures is that of showing the ventro-ventral ray of the bursa split lengthwise, a condition not found in any specimens examined by me. I have also failed to find any appearance of transverse striation of the cuticle except in the head region, while Curtice's description indicates that the body is transversely striate throughout. Taking everything into consideration, however, there can be no reasonable doubt that the form which I have described above is the true *Strongylus curticei*.

The form from European cattle which Schnyder (1906b, pl. 2, fig. 5) figures as *Strongylus curticei* Giles, and specimens of which I have had the privilege of examining through the courtesy of Doctor Schnyder, is not that species but evidently *Cooperia oncophora*.

Cooperia punctata (Linstow, 1907) Ransom, 1907.

(Figs. 72-77.)

1906: *Strongylus* sp. Schnyder, 1906b, pp. 182, 183, 186, 193, 194, 195, 196, 199, 204, 245, 249, 264, pl. 1, figs. 2-3.

1907: *Strongylus punctatus* Linstow in Schnyder, 1907d, pp. 708-709.

1907: *Cooperia punctata* (Schnyder, 1907) Ransom, 1907k, p. 3.

1907: *Strongyloides bovis* Vrijburg, 1907k, pp. 321-327, pls. 1-2 (at least in part).

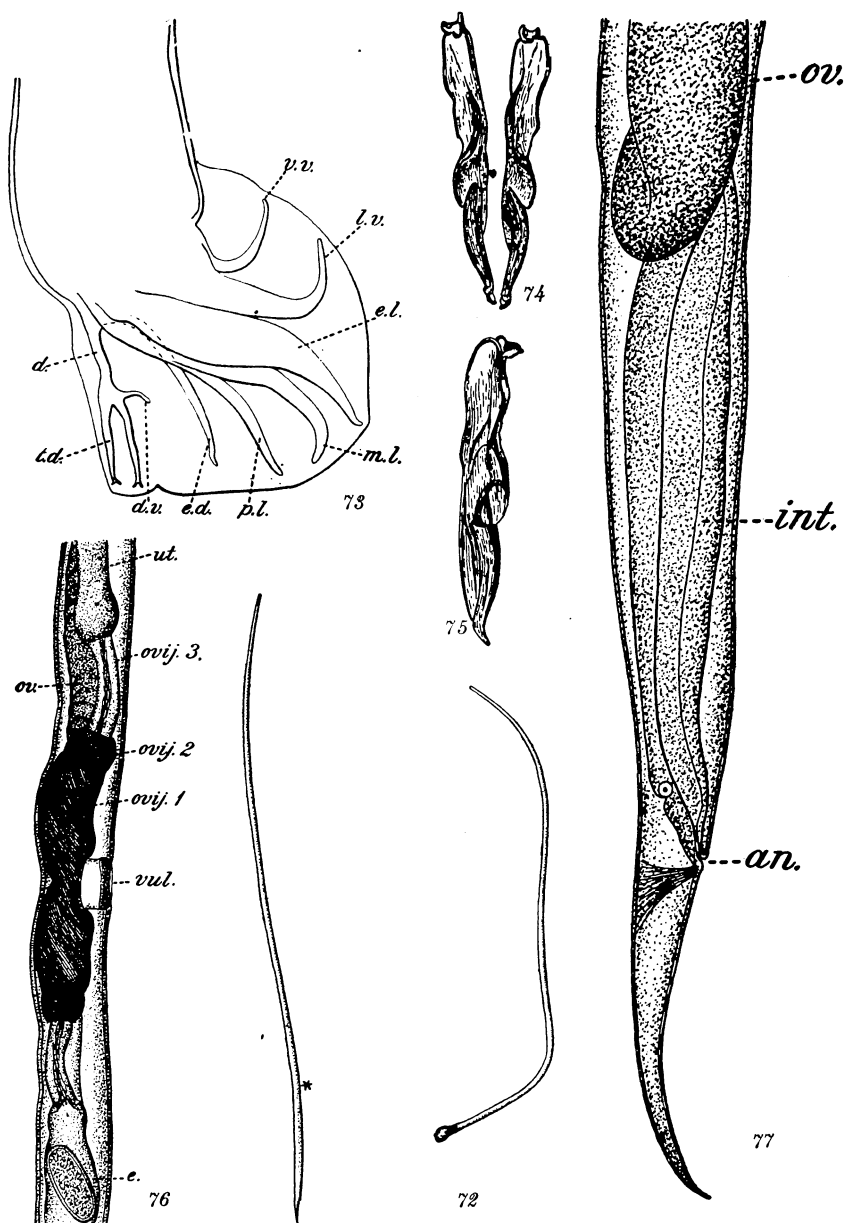


FIG. 72.—*Cooperia punctata*. Male at right, female at left. *Vulva. $\times 15$. (Original.)

FIG. 73.—*Cooperia punctata*. Bursa of male, viewed from right side. *d.*, dorsal ray; *d. v.*, ventral branch of dorsal ray; *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *t. d.*, terminal branch of dorsal ray; *v. v.*, ventro-ventral ray. $\times 300$ (Original.)

FIG. 74.—*Cooperia punctata*. Spicules of male. Ventral view. $\times 300$. (Original.)

FIG. 75.—*Cooperia punctata*. Spicule of male. Lateral view. $\times 300$. (Original.)

FIG. 76.—*Cooperia punctata*. Body of female in region of vulva, viewed from right side. *e.*, egg; *ov.*, ovary; *ovij. 1*, terminal portion of ovjector; *ovij. 2*, sphincter of ovjector; *ovij. 3*, nonmuscular portion of ovjector; *ut.*, uterus; *vul.*, vulva. $\times 150$. (Original.)

FIG. 77.—*Cooperia punctata*. Posterior end of body of female, viewed from right side. *an.*, anus; *int.*, intestine; *ov.*, ovary. $\times 300$. (Original.)

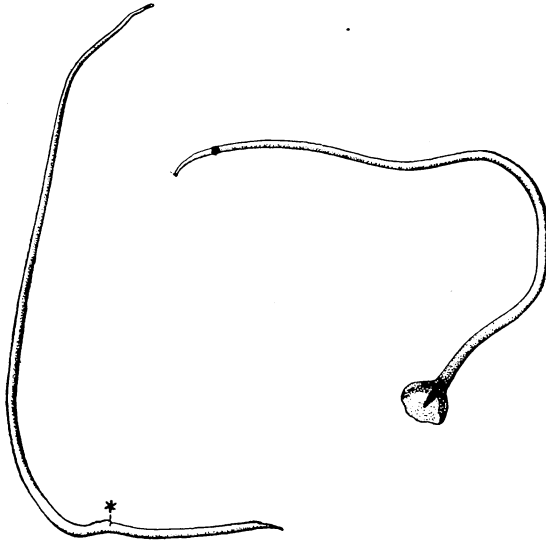


FIG. 78.—*Cooperia oncophora*. Male at right, female at left. *Vulva. $\times 15$. (Original.)

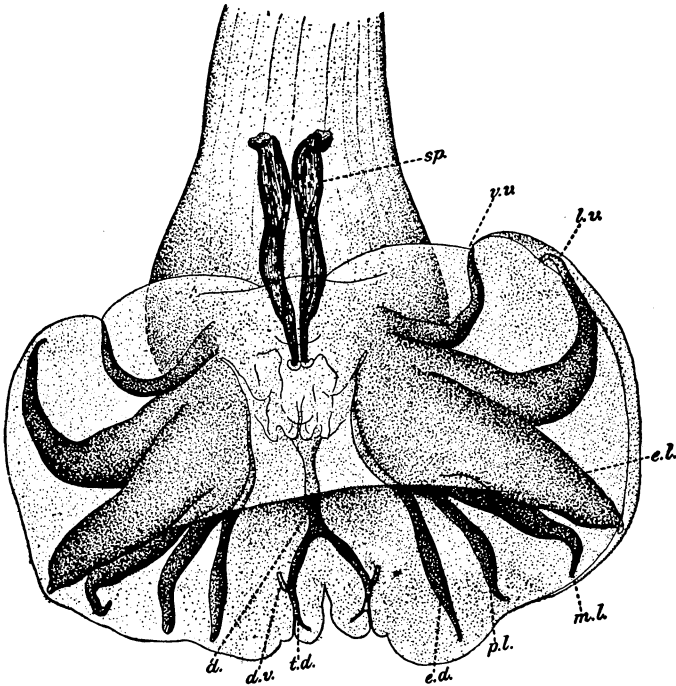


FIG. 79.—*Cooperia oncophora*. Posterior end of body of male, with bursa spread out. Ventral view. *d.*, dorsal ray; *d. v.*, ventral branch of dorsal ray; *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *sp.*, spicule; *t. d.*, terminal branch of dorsal ray; *v. v.*, ventro-ventral ray. $\times 100$. (Original.)

SPECIFIC DIAGNOSIS.—*Cooperia* (p. 69): Head 30 to 55 μ in diameter, varying according to the degree of expansion of the cuticle. Esophagus 255 to 360 μ in length in the male and 300 to 340 μ in length in the female, surrounded by a nerve ring at a distance of about three-fourths of its length from the anterior end. The esophagus is about 20 μ in diameter at its beginning, is then reduced in size for a short distance, after which it gradually increases to a maximum of 30 to 35 μ at its posterior end.

Male 4.7 to 5.9 mm. long by 70 to 100 μ in maximum diameter at the base of the bursa. The latero-ventral ray (*l. v.*, fig. 73) is considerably more slender than the externo-lateral ray (*e. l.*, fig. 73), which is the thickest of all the rays. The latero-ventral ray (*l. v.*, fig. 73) comes next in thickness, then the medio-lateral (*m. l.*, fig. 73), postero-lateral (*p. l.*, fig. 73), externo-dorsal (*e. d.*, fig. 73), and finally the ventro-ventral ray (*v. v.*, fig. 73), which is the most slender of the paired rays. The tips of the rays are close to the edge of the bursa except that of the externo-dorsal ray, which is some distance from the edge, the externo-dorsal ray being proportionately shorter in this species than in *C. curticei*. Of the paired rays the tips of the medio-lateral and postero-lateral rays are the most closely approximated to each other. The stem of the dorsal ray (*d.*, fig. 73) and its branches are about equal in length to those of *C. curticei*, the stem, however, being somewhat longer, about 40 μ in length, with branches 30 to 35 μ in length. As in *C. curticei* the branches (*t. d.*, fig. 73) are usually cleft at the end, and each gives off a ventral branch (*d. v.*, fig. 73) at its origin, but they differ from those in the other species in being nearly straight and almost parallel instead of forming a lyre-shaped structure. The spicules (figs. 74, 75) measure 120 to 150 μ in length, are without corrugated markings, but exhibit near the middle on the ventral side a deep concavity.

Female 5.7 to 7.5 mm. long by 65 to 75 μ in maximum diameter in the region of the vulva. The vulva (*vul.*, fig. 76) has prominent chitinous lips, is crescentic in shape, elongated longitudinally, measures 40 to 50 μ in length, and is situated 1 to 1.5 mm. from the posterior end of the body. The tail (fig. 77) is slender, tapering, acutely pointed, slightly concave ventrally, very similar in shape to that of *C. curticei*. The anus (*an.*, fig. 77) is located 135 to 160 μ from the tip of the tail. Combined length of muscular portions of ovijectors (*ovij. 1-2*, fig. 76), including the sphincters, 250 to 275 μ . The eggs (*e.*, fig. 76) measure 65 to 72 μ in length by 30 μ in width.

HOST.—*Cattle (*Bos taurus*).

LOCATION.—Small intestine and fourth stomach.

LOCALITIES COLLECTED.—Europe, United States, Sumatra.

Comparison of European specimens (B. A. I. Coll. Nos. 15726, 15729, 15732, 15733, presented by Dr. O. Schnyder) with specimens from American cattle has demonstrated the identity of the European and American forms.

The form from cattle in Sumatra described by Vrijburg (1907k, pp. 321–327, pls. 1–2) and named by him *Strongyloides bovis*, is very clearly not a *Strongyloides*. His description and figures indicate that he was dealing with *Cooperia punctata*, in part at least.

Cooperia oncophora (Railliet, 1898) Ransom, 1907.

(Figs. 78–82.)

1803: *Strongylus radiatus* Rudolphi, 1803a, pp. 13–15 (in part; see Schneider, 1866a, p. 139).

1866: *Strongylus ventricosus* Rudolphi of Schneider, 1866a, pp. 129, 131, 132, 139, 144 (in part).

1898: *Strongylus oncophorus* Railliet, 1898b, p. 173 (*S. ventricosus* Rudolphi of Schneider, 1866, renamed).

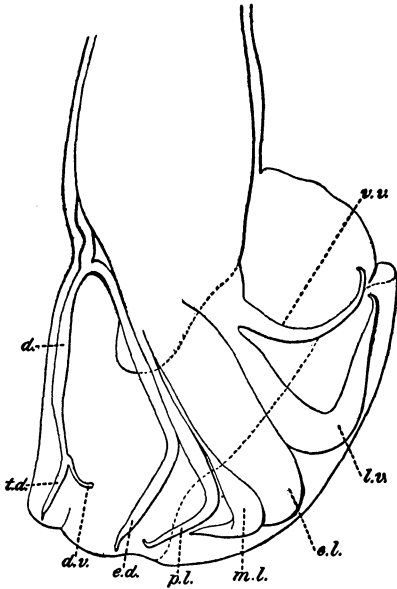


FIG. 80.—*Cooperia oncophora*. Bursa of male, viewed from right side. *d.*, dorsal ray; *d.v.*, ventral branch of dorsal ray; *e.d.*, externo-dorsal ray; *e.l.*, externo-lateral ray; *l.v.*, latero-ventral ray; *m.l.*, medio-lateral ray; *p.l.*, postero-lateral ray; *t.d.*, terminal branch of dorsal ray; *v.v.*, ventro-ventral ray. $\times 100$. (Original.)



FIG. 81.—*Cooperia oncophora*. Spicule of male. Lateral view. $\times 300$. (Original.)

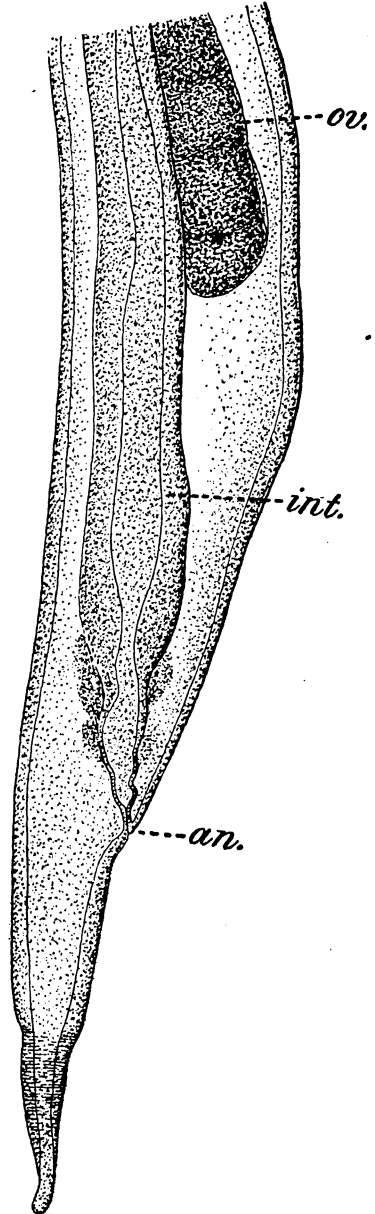


FIG. 82.—*Cooperia oncophora*. Posterior end of body of female, viewed from right side. *an.*, anus; *int.*, intestine; *ov.*, ovary. $\times 300$. (Original.)

1906: *Strongylus curticei* Giles of Schnyder, 1906b, pp. 169, 181, 182, 183, 190, 191, 192, 193, 194, 199, 204, 205, 207, 245, 246, 247, 249, 251, 256, 258, 259, 264, pl. 2, fig. 5 (misdetermination).

1907: *Cooperia oncophora* (Railliet, 1898) Ransom, 1907k, pp. 3-4.

SPECIFIC DIAGNOSIS.—*Cooperia* (p. 69): Male 5.5 to 9 mm. long by 150 to 250 μ wide at the base of the bursa, in which region the thickness of the body undergoes a considerable and rather sudden increase. Head 25 to 40 μ in diameter, varying according to the degree of expansion of the cuticle. Esophagus 320 to 440 μ long by 18 to 24 μ in thickness anteriorly, increasing in size after passing the nerve ring, which is located slightly posterior of the middle of the esophagus, and reaching a maximum of 35 to 40 μ at the posterior end. Bursa (figs. 79, 80) large when spread out, about three times as wide as the maximum thickness of the body. Border of the median lobe incised in the median line, also with small incisions corresponding to the terminations of the posterior branches of the dorsal ray. Dorsal ray (*d.*, figs. 79, 80) 220 to 400 μ long, including a long slender stem 140 to 250 μ in length. The branches of the dorsal ray form a somewhat horseshoe-shaped or U-shaped arch, from each of which a ventral branch (*d. v.*, figs. 79, 80) comes off near the middle, and each is cleft at the end. Externolateral ray (*e. l.*, figs. 79, 80) very thick, somewhat thicker than the latero-ventral ray (*l. v.*, figs. 79, 80), which is the thickest of the remaining rays, next in thickness being the medio-lateral ray (*m. l.*, figs. 79, 80), then the postero-lateral (*p. l.*, figs. 79, 80), and ventro-ventral (*v. v.*, figs. 79, 80) rays, which are of about equal thickness, and finally the externo-dorsal ray (*e. d.*, figs. 79, 80) which is the slenderest of the paired rays. Spicules (fig. 81; *sp.*, fig. 79) 240 to 300 μ long, of comparatively simple structure, gradually reduced in thickness posteriorly, without prominent projecting edges, corrugations, or excisions.

Female 6 to 8 mm. long by 120 to 190 μ in maximum thickness in the region of the vulva where there is a more or less prominent belly-like enlargement. Head 28 to 40 μ in diameter, varying according to the degree of expansion of the cuticle. Thickness of the body 45 to 75 μ at the base of the esophagus, 35 to 50 μ at the anus. Esophagus 280 to 415 μ in length by 18 to 24 μ in diameter anteriorly, the diameter remaining almost equal until the nerve ring is reached, after which it increases, reaching a maximum of 30 to 40 μ at the posterior end. Nerve ring slightly posterior of the middle of the esophagus. Tail (fig. 82) slender with rounded tip. Anus (*an.*, fig. 82) about 160 μ from the tip of the tail. Beginning some distance in front of the anus the posterior end of the body is gradually reduced in size passing backward, and at a distance of about 75 μ from the tip of the tail there is frequently a more sudden decrease, and the posterior portion of the tail thus set off is marked with annular striations. The vulva is located 1.6 to 1.9 mm. from the posterior end of the body. Its shape was not well defined in the specimens examined, but it is apparently elongated transversely. Combined length of the muscular portions of the ovijectors, including the sphincters, about 700 μ . Eggs 60 to 80 μ long by 30 μ wide.

Hosts.—*Cattle (*Bos taurus*); *sheep (*Ovis aries*); *mountain sheep (*Ovis canadensis*).

LOCATION.—Small intestine.

LOCALITIES COLLECTED.—Europe and United States.

Considerable variation has been noticed in the specimens which I have assigned to the species *Cooperia oncophora*, and it is possible that a division of the species will be necessary. Such a division, however, should be attempted only after a careful comparative study of a larger number of specimens than have been available in the preparation of the present paper.

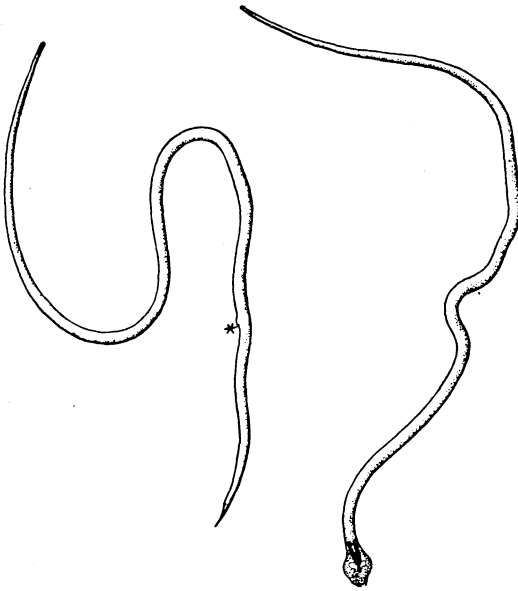


FIG. 83.—*Cooperia pectinata*. Male at right., female at left.
*Vulva. $\times 15$. (Original.)

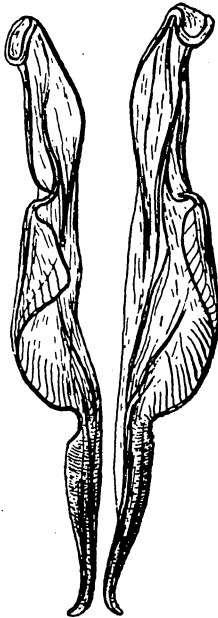


FIG. 84.—*Cooperia pectinata*. Spicules of male. Ventral view. $\times 300$. (Original.)

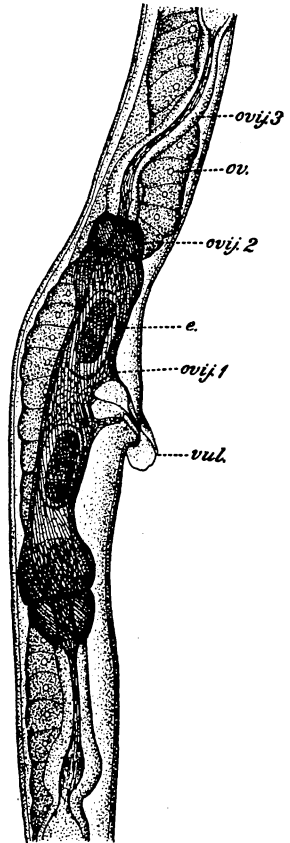


FIG. 85.—*Cooperia pectinata*. Body of female in region of vulva, viewed from right side. *e.*, egg; *ov.*, ovary; *ovij. 1*, terminal portion of ovjector; *ovij. 2*, sphincter of ovjector; *ovij. 3*, nonmuscular portion of ovjector; *vul.*, vulva. $\times 150$. (Original.)

***Cooperia pectinata* Ransom, 1907.**

(Figs. 83-86.)

1907: *Cooperia pectinata* Ransom, 1907k, pp. 3-4
(from *Bos taurus*, United States).

SPECIFIC DIAGNOSIS.—*Cooperia* (p. 69): *Male* about 7 mm. long by 130 to 160 μ in maximum thickness at the base of the bursa. Head about 32 μ in diameter, larger if cuticle is expanded. Diameter of body at base of esophagus about 50 μ . Esophagus 400 μ in length, about 20 μ in diameter, increasing in size beyond the nerve ring and reaching its maximum of about 35 μ at the posterior end. Nerve ring 280 μ from anterior end of esophagus. Latero-ventral and externo-lateral rays of the bursa much thicker than any of the others. Length of dorsal ray including its terminal branches which are parallel to one another and uncleft at the end is at least 180 μ . Spicules (fig. 84) 240 to 280 μ long, distal third much more slender than remainder, middle third with a prominent curved ventrally-projecting edge corrugated on the inner surface.

Female 7.5 to 9 mm. long by 110 to 135 μ in maximum diameter in the neighborhood of the vulva. Head 35 to 50 μ in diameter, varying according to degree of expansion of the cuticle. Diameter of body at base of esophagus 50 to 60 μ , at anus about 40 μ . Esophagus 360 to 400 μ long, 18 to 24 μ in diameter in front of nerve ring, increasing to 35 or 40 μ at the posterior end. Nerve ring 250 to 280 μ from anterior end of esophagus. Posterior end of body (fig. 86) gradually attenuated backward, beginning at the posterior loop of the posterior ovary or uterus (*ut.*, fig. 86), terminating in a slender sharply pointed tail. Anus (*an.*, fig. 86) about 175 μ from the tip of the tail. Vulva (*vul.*, fig. 85) 1.6 to 2 mm. from the tip of the tail, its opening transversely elongated, with projecting vesicular lips. Combined length of muscular portions of ovijectors (*ovij. 1-2*, fig. 85) including the sphincters about 300 μ . Musculature of ovijectors only very slightly developed in the region toward the point of union with the vagina. Eggs (*e.*, fig. 85) 70 to 80 μ long by 36 μ wide.

HOST.—Cattle (*Bos taurus*).

LOCATION.—Fourth stomach.

LOCALITY COLLECTED.—Texas.

TYPE SPECIMENS.—Bureau of Animal Industry Helminthological Collection No. 4208, collected in 1900 in Texas by Dr. C. W. Stiles.

This species has been collected but once, a few specimens being present

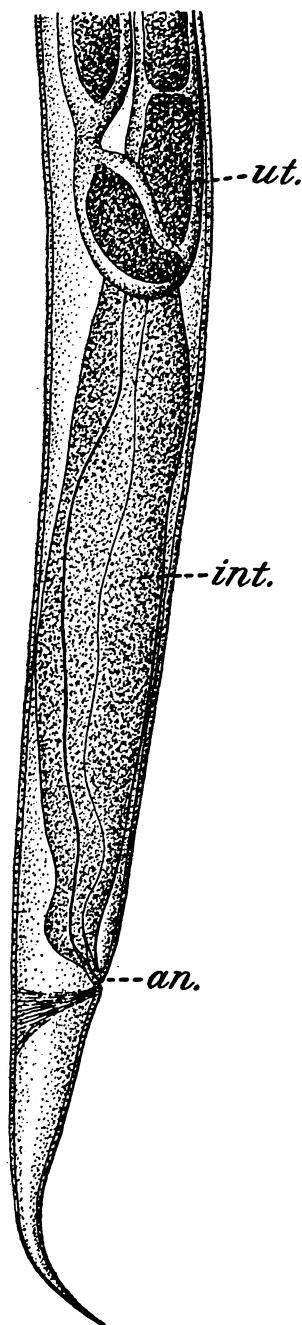


FIG. 86.—*Cooperia pectinata*. Posterior end of body of female, viewed from right side. *an.*, anus; *int.*, intestine; *ut.*, uterus. $\times 300$. (Original.)

among some nematodes taken from the fourth stomach of a Texas cow. These nematodes are mostly *Hæmonchus contortus*, but *Trichostrongylus extenuatus*, *Ostertagia ostertagi*, and *Cooperia punctata* are also represented.

Genus NEMATODIRUS Ransom, 1907.

1907: *Nematodirus* Ransom, 1907k, p. 4.

GENERIC DIAGNOSIS.—*Metastrongylinae* (p. 47): Head not over 50μ in diameter; circumoral papillae inconspicuous. Cuticle of head may be slightly inflated and in cervical region striated transversely. Cervical papillae apparently absent. Bursa without unpaired dorsal median ray. Dorsal lobe of bursa reduced to two small short lobules, each supported by a dorsal ray. Ventro-ventral and latero-ventral rays of each lateral lobe of bursa close together, parallel. Six supporting rays in each lateral lobe. Medio-lateral and postero-lateral rays close together, parallel. Externolateral ray distally diverges widely from the other lateral rays. Spicules more than 0.5 mm. in length, slender, tubular, filiform, united by a membrane throughout their length, or only in their distal portion. Gubernaculum absent. Vulva of female behind the middle of the body. Ovijectors well developed. Eggs large, generally over 150μ long.

TYPE-SPECIES.—*Nematodirus filicollis* (Rudolphi, 1802) Ransom, 1907.

Three species which may be assigned to the genus *Nematodirus* have been reported as parasites of ruminants.

KEY TO SPECIES OF NEMATODIRUS.

- | | |
|--|---------------------------------------|
| 1. Length of spicules of male about 1 mm.; tail of female blunt; eggs more than 150μ long | 2 |
| Length of spicules of male about 4.5 mm.; tail of female pointed; eggs 97μ long by 53μ wide; male 24 mm. long, female 29 mm. long. | |
| | <i>Nematodirus digitatus</i> , p. 85 |
| 2. Eggs 170 to 200μ long; male 8 to 15 mm. long, female 12 to 20 mm. long. | |
| | <i>Nematodirus filicollis</i> , p. 82 |
| Eggs about 260μ long; male 14 to 19 mm. long, female 26 to 29 mm. long. | |
| | <i>Nematodirus spathiger</i> , p. 85 |

Nematodirus filicollis (Rudolphi, 1802) Ransom, 1907.

(Figs. 87-92.)

- 1802: *Ascaris filicollis* Rudolphi, 1802a, pp. 23–25, pl. 1, fig. 1, a, b, c (from *Ovis aries*, Germany).
 1803: *Strongylus filicollis* (Rudolphi, 1802) Rudolphi, 1803a, pp. 17–18.
 1803: *Fusaria filicollis* (Rudolphi) Zeder, 1803a, p. 110 (*Ascaris filicollis* Rudolphi, 1802, renamed).
 1907: *Nematodirus filicollis* (Rudolphi) Ransom, 1907k, p. 4.

SPECIFIC DIAGNOSIS.—*Nematodirus* (p. 82): Body slender, tapering gradually toward the anterior extremity; head (fig. 88) between 25 and 50 μ in diameter; cuticle of head and neck may be slightly inflated, in latter region coarsely striated transversely, elsewhere without transverse striations. Four and probably six inconspicuous circum-oral papillae. Mouth small, followed directly by the esophagus, no buccal capsule. Esophagus 400 to 500 μ long. Cervical papillae not apparent. Lateral membranes absent.

Male 8 to 15 mm. long by 125 to 175 μ in maximum diameter. Bursa (figs. 89, 90) with two large lateral lobes. Dorsal lobe short, deeply emarginate, and thus reduced

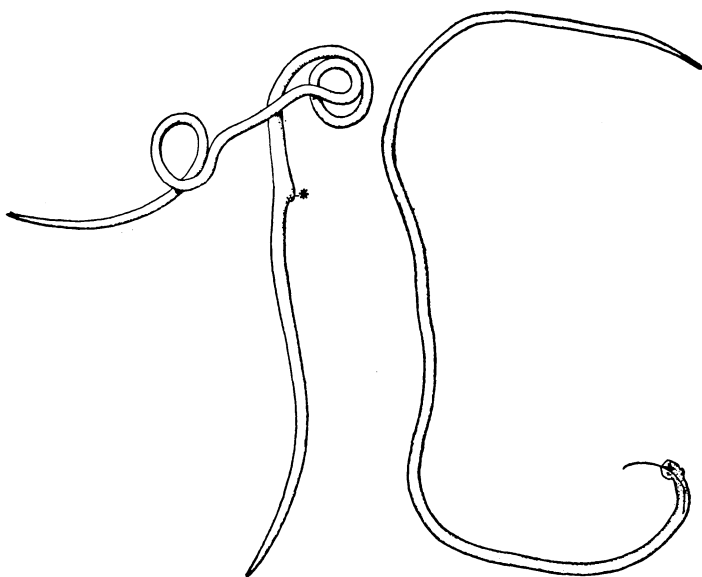


FIG. 87.—*Nematodirus filicollis*. Male at right, female at left. *Vulva. $\times 15$. (Original.)



FIG. 88.—*Nematodirus filicollis*. Anterior end of body. $\times 150$. (Original.)

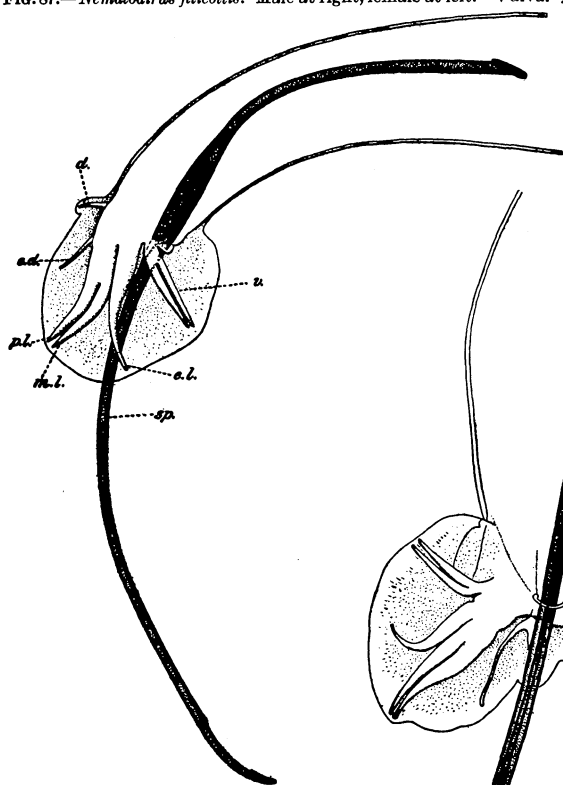


FIG. 90.—*Nematodirus filicollis*. Posterior end of body of male, viewed from right side. *d.*, dorsal ray; *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *sp.*, spicule; *v.*, ventral rays. $\times 150$. (Original.)

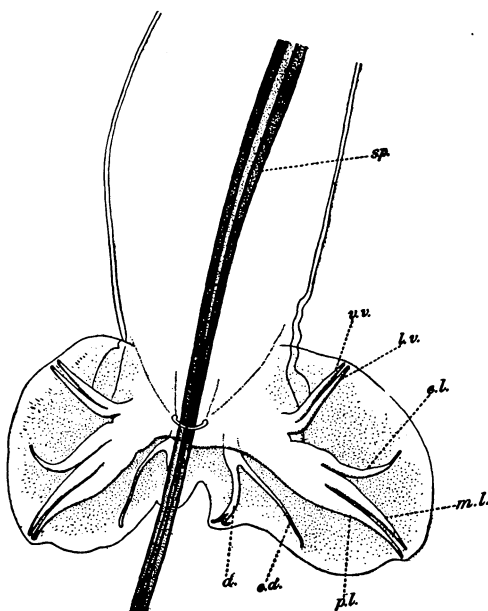


FIG. 89.—*Nematodirus filicollis*. Posterior end of body of male. Ventral view. *d.*, dorsal ray; *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *sp.*, spicules; *v. v.*, ventro-ventral ray. $\times 150$. (Original.)

to two small lobules. Ventral rays (*v. v.*, *l. v.*, *v.*, figs. 89, 90) slender, close together, parallel. Externo-lateral ray (*e. l.*, figs. 89, 90) at first close to the medio-lateral ray (*m. l.*, figs. 89, 90), distally curves ventralward away from the latter. Distally the medio-lateral and postero-lateral (*p. l.*, figs. 89, 90) rays curve slightly dorsalward. Medio-lateral and postero-lateral rays close together throughout their entire length, the tip of the latter extending slightly beyond that of the former. Tip of the postero-lateral ray about equidistant from the tip of the externo-dorsal ray and the tip of the externo-lateral ray, the latter being about the same distance from the tip of the latero-

ventral ray. Lateral rays thicker than the other rays. Externo-dorsal ray (*e. d.*, figs. 89, 90) very slender. No median dorsal ray. Each dorsal lobule of the bursa is sustained by a ray (*d.*, figs. 89, 90) whose base is united with the base of the

externo-dorsal ray, somewhat thicker than the latter, with bifid tip. Spicules (*sp.*, figs. 89, 90) slender, equal, about 1 mm. long, united by a membrane in the posterior two-thirds, more closely toward the tip, where the membrane forms a spatulate enlargement. Prebursal papillae small, inconspicuous.

Female 12 to 20 mm. long with a maximum thickness of 200 to 250 μ at the vulva. Thickness suddenly reduced just behind the vulva. Tip of tail (fig. 92) truncate, bearing a short slender acutely pointed bristle-like process. Anus (*an.*, fig. 92) 70 to 80 μ from the truncated end of the body. Vulva (*vul.*, fig. 91) a transverse slit located about one-third the length of the body from

the posterior end. Combined length of the muscular portions of the two ovjectors (*ovij. 1-2*, fig. 91) including the sphincters about 400 μ . Eggs (*e.*, fig. 91) oval, 175 to 200 μ long by about 100 μ wide. Embryos develop into filariform larvæ before hatching.

Hosts.—*Cattle (*Bos taurus*); *sheep (*Ovis aries*); *goat (*Capra hircus*); *pronghorned antelope (*Antilocapra americana*); *roe deer (*Capreolus capreolus*); fallow deer (*Dama dama*).

Location.—Small intestine.

Localities collected.—United States, Europe, New Zealand, Australia.

This species is of rather common occurrence in the United States, but as a rule is not found in large numbers, and probably in conse-

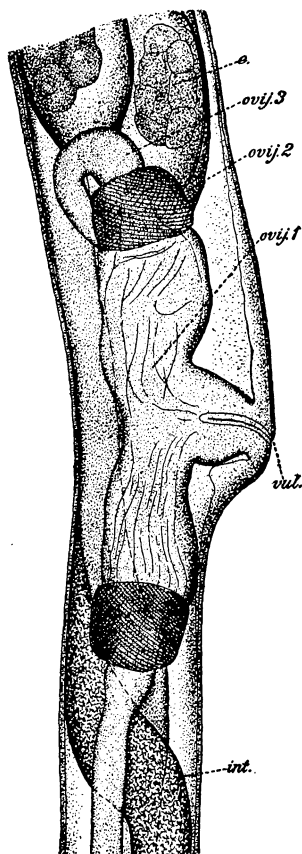


FIG. 91.—*Nematodirus filicollis*. Body of female in region of vulva, viewed from right side. *e.*, egg; *int.*, intestine; *ovij. 1*, terminal portion of ovjector; *ovij. 2*, sphincter of ovjector; *ovij. 3*, nonmuscular portion of ovjector; *vul.*, vulva. $\times 150$. (Original.)

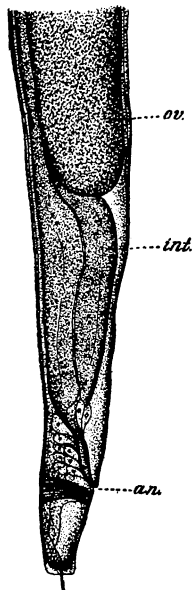


FIG. 92.—*Nematodirus filicollis*. Posterior end of body of female, viewed from right side. *an.*, anus; *int.*, intestine; *ov.*, ovary. $\times 150$. (Original.)

quence does not seriously affect the health of animals which it infests. An interesting point in regard to its development is that the embryo develops into a larva with the filariform type of esophagus before hatching, thus differing from other strongyles, such as *Hæmonchus contortus*, in which the newly hatched embryo possesses a rhabditi-form esophagus with posterior bulb, not developing into the larval stage with filariform esophagus until later.

Nematodirus spathiger (Railliet, 1896) Railliet and Henry, 1909.

1896: *Strongylus spathiger* Railliet, 1896m, p. 490.

1909: *Nematodirus spathiger* (Railliet) Railliet and Henry, 1909a, p. 87.

SPECIFIC DIAGNOSIS.—*Nematodirus* (p. 82): Color reddish. Body much attenuated anteriorly. Head provided with an expansion. Mouth bordered by membranous lips. Esophagus very long, claviform.

Male 14 to 19 mm. long and 180 to 200 μ in maximum thickness. Its maximum thickness is attained toward the posterior third of the body. Bursa with lateral lobes well developed; posterior lobe so deeply emarginate that it is reduced to two weakly developed lobules. Each dorsal lobule supported by a dorsal ray, which is divided distally into two branches, of which the outer one is slightly the longer and curved outward. Externo-dorsal ray very slender. The spicules, united at their extremity by a spatulate membranous lamella, measure 1 mm. in length.

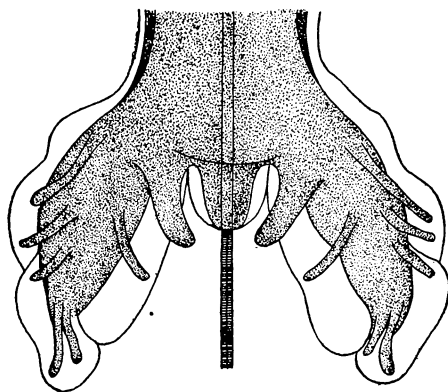


FIG. 93.—*Nematodirus digitatus*. Posterior end of body of male. Enlarged. (After Linstow, 1906, pl. 1, fig. 10.)

Female 26 to 29 mm. long, gradually increasing in thickness until the vulva is reached, in which region the body measures as much as 460 μ . Immediately behind the vulva the body is reduced in size, then increased again in the region of the posterior oviduct, and finally diminishes in size toward the tip of the tail, which is very blunt. Vulva situated about one-fourth the length of the body from the posterior end. Eggs very large, ovoid-oblong, with thin shells a little thickened at one pole; average size 260 μ long by 103 μ wide; in course of segmentation when deposited.

Host.—Arabian camel (*Camelus dromedarius*).

LOCATION.—Small intestine.

LOCALITY COLLECTED.—France.

The foregoing diagnosis is based on Railliet's (1896m) brief description.

Nematodirus digitatus (Linstow, 1906) Railliet and Henry, 1909.

(Fig. 93.)

1906: *Strongylus digitatus* Linstow, 1906, Spolia Zeylanica, Colombo, pt. 11, v. 3, Jan., pp. 163, 168, pl. 1, fig. 10 (from stomach of *Bibos indicus* (= *Bos indicus*), Ceylon).

1909: *Nematodirus digitatus* (Linstow) Railliet and Henry, 1909a, p. 87.

SPECIFIC DIAGNOSIS.—*Nematodirus* (p. 82): Cuticle without longitudinal lines, but with very fine annulation; head attenuate, mouth surrounded by four papillæ; esophagus of male $\frac{1}{4}$, of female $\frac{1}{7}$ the body length; the nerve ring surrounds the esophagus at the limit of the first and second quarters and the excretory pore opens below it.

Male 24 by 0.36 mm.; spicules very long, 4.54 mm., coalescent throughout their entire length and thickened fusiform at the end; the lateral lobes of the bursa are curved claw-like inwardly; each lobe is supported by six ribs, of which one lies at the inner margin, two side by side at the outer margin; there is no median lobe; the end of the body is rounded with a pair of finger-shaped, slightly curved hyaline cuticular lobes. (?=lobules of the reduced dorsal median lobe—B. H. R.)

Female 29 by 0.47 mm.; genital orifice lies far back, dividing the body in the ratio 8:1; tail pointed, $\frac{1}{18}$ the body length; eggs 97 by 53 μ .

Host.—Zebu (*Bos indicus*).

LOCATION.—Stomach.

LOCALITY COLLECTED.—Ceylon.

The foregoing description is taken from Linstow (1906, *Spolia Zeylanica*, Colombo, pt. 11, v. 3, Jan., p. 163). He remarks particularly upon one difference between this species and *Nematodirus filicollis*, namely, the absence of longitudinal lines on the cuticle of the former, and the presence of 18 longitudinal ridges in the latter.

Genus TRICHOSTRONGYLUS Looss, 1905.

1905: *Trichostrongylus* Looss, 1905o, pp. 409–422, pls. 1–2, figs. 1–14.

GENERIC DIAGNOSIS.—*Metastrongylinae* (p. 47): Small and slender; color reddish. Body gradually attenuated forward from the genital opening. Head only about 10 μ in diameter, with three small lips and nodular or punctiform papillæ. Cuticle with annular striations and without longitudinal ridges. Cervical papillæ lacking. Buccal cavity not well differentiated. Esophagus long, with simple well-developed dorsal gland. Nerve ring and excretory pore about 150 μ from the anterior end. Body of the cervical glands behind the esophagus, one in front of the other. Bursa with large lateral lobes, without well-developed median lobe. Six supporting rays in each lateral lobe. Ventral rays widely separated, of very different thickness. Ventro-ventral ray thin and directed ventrally; latero-ventral ray thick and in close relation with the lateral rays. Postero-lateral ray thinner than the other lateral rays and located close to the externo-dorsal ray. Dorsal ray short, cleft at the end. Spicules short, not twisted, but spoon-shaped or spatula-shaped. Anterior end of spicule thickened, with a knob-like or disk-like process toward one side. Toward the posterior end of the spicule a more or less prominent angular projection is usually present, giving the point of the spicule a hooked or barbed appearance. Gubernaculum or accessory piece present, elongated and boat-shaped or shoe-shaped in profile. Prebursal papillæ small. Testicle simple, uncoiled. Ovaries in older individuals slightly wavy, the anterior one disposed in one or several longitudinal loops. Ovijectors well developed. Vulva in the posterior half of the body, slit-shaped, straight or crescentic, surrounded by somewhat protruding chitinous lips. Postanal portion of the body of female relatively short, with a pair of small caudal papillæ near the tip. Eggs of moderate size, thin shelled, colorless, containing a maximum number of 8 to 32 cells when deposited. Parasitic in the duodenum, more rarely in the stomach of herbivorous animals.

TYPE SPECIES.—*Trichostrongylus retortæformis* (Zeder, 1800) Looss, 1905.

Nematodes of the genus *Trichostrongylus* often occur in ruminants in enormous numbers. In autopsies of goats dying with symptoms of parasitic disease I have found the small intestine and fourth stomach containing large felt-like masses of worms, composed mostly of *Trichostrongylus instabilis* in the intestine and *T. extenuatus* in the fourth stomach. The latter species has been found associated with gastro-enteritis in cattle in England by McFadyean (1896b).

This genus is of interest to human medicine, as three of its species, *T. instabilis*, *T. probolurus*, and *T. vitrinus*, occur parasitic in man as well as in ruminants. Although all three occur in the United States, they have not yet been reported as parasites of man in this country.

Six species of *Trichostrongylus* are known to be parasitic in ruminants.

KEY TO SPECIES OF TRICHOSTRONGYLUS.

(The imperfectly known *Trichostrongylus colubriiformis* (p. 90) is not included in this key.)

1. Spicules of male unequal in size, right spicule 85 to 95 μ long, left spicule 110 to 120 μ long; gubernaculum 50 to 60 μ long; postero-lateral ray of bursa as long as either of the other two lateral rays and nearly as wide; male 3.4 to 4.4 mm. long, female 4.6 to 5.5 mm. long..... *Trichostrongylus extenuatus*, p. 94
 Spicules of male equal in size, more than 125 μ in length; postero-lateral ray of bursa usually considerably shorter and narrower than the other lateral rays..... 2
2. Spicules 160 to 170 μ long, sharply pointed, without hook-like projection; bursa relatively large; externo-lateral ray widest of the rays; male 4 to 4.5 mm. long, female 5 to 6.5 mm. long..... *Trichostrongylus vitrinus*, p. 92
 Spicules less than 150 μ long..... 3
3. Spicules with a hook-like projection on the ventral surface near the tip; postero-lateral ray of bursa much shorter than the other lateral rays..... 4
 Spicules without hook-like projection, distal half bent ventralward at an angle of about 140 degrees; spicules 130 to 145 μ long; latero-ventral ray of bursa longest and widest of the rays; postero-lateral ray nearly as long as the other lateral rays; male 4.3 to 4.9 mm. long, female 5.8 to 6.8 mm. long.
Trichostrongylus capricola, p. 96
4. Spicules relatively thick, 126 to 134 μ long, hook-like projection high and sharply defined, in front of it a second angular projection, giving the spicules a gnarled or twisted appearance under low magnification; latero-ventral ray of bursa much the thickest of the rays; postero-lateral and external-dorsal ray very short and close together; tail of female short and rather blunt; male 4.5 to 5.5 mm. long, female 4.5 to 6 mm. long..... *Trichostrongylus probolurus*, p. 90
 Spicules relatively slender, 135 to 145 μ long, hook-like projection sharply defined but not high; externo-lateral ray usually thicker than any of the others, rarely of about the same thickness as the latero-ventral ray; tail of female rather slender, sharply pointed; male 4 to 5.5 mm. long, female 5 to 6 mm. long.

Trichostrongylus instabilis, p. 88

Trichostrongylus instabilis (Railliet, 1893) Looss, 1905.

(Figs. 94-97.)

1892: *Strongylus colubriiformis* Giles, 1892c, p. 34 (possibly identical with *T. instabilis*).

1893: *Strongylus instabilis* Railliet, 1893a, p. 442, fig. 301.

1895: *Strongylus subtilis* Looss, 1895b, pp. 161-169, pl. 1, figs. 1-8.

1898: *Strongylus retortæformis* Zeder of Railliet, 1898b, p. 174 (in part).

1905: *Trichostrongylus subtilis* Looss, 1905o, pp. 417, 418-419, pl. 1, figs. 4-8.

1905: *Trichostrongylus instabilis* (Railliet, 1893), Looss, 1905o, p. 422.

SPECIFIC DIAGNOSIS.—*Trichostrongylus* (p. 86): *Male* 4 to 5.5 mm. long and about 80μ thick in front of bursa. The externo-lateral ray (*e. l.*, fig. 95) is usually thicker (lateral view) than any of the others, rarely of about the same thickness as the latero-ventral ray (*l. v.*, fig. 95). Postero-lateral ray (*p. l.*, fig. 95) noticeably smaller than the other lateral rays and closer to the externo-dorsal ray (*e. d.*, fig. 95) than to the other lateral rays; its end is often bent toward that of the externo-dorsal ray, so that the distance between the postero-lateral and externo-dorsal papillæ is less than that between the latter and the dorsal ray. Dorsal ray (*d.*, fig. 95) split near the end, each branch ending in a double point. Spicules (fig. 96) 135 to 145μ long. Gubernaculum about 70μ long, of bright yellowish-brown color, and relatively slender. Terminal hook of the spicules long and sharply defined, but not high.

Female 5 to 6 mm. long, 80μ wide at the level of the genital opening (1.05 to 1.2 mm. from tip of tail). Body becomes but slightly thinner toward the anus (*an.*, fig. 97), behind which it narrows rather suddenly to form a slender and very sharp tail. The latter is often bent a little dorsalward. Distance between anus and tip of tail 55 to 70μ . Vulva elongated longitudinally, relatively short, 50 to 55μ long, including its lips. Combined length of muscular portions of ovijectors, including the sphincters, 400 to 500μ . Eggs 73 to 76μ , rarely 80μ , long, and 40 to 43μ wide.

Hosts.—*Sheep (*Ovis aries*); Dorcas gazelle (*Gazella dorcas*); *Arabian camel (*Camelus dromedarius*); *Bactrian camel (*Camelus bactrianus*); Arabian baboon (*Papio hamadryas*); man (*Homo sapiens*); *goat (*Capra hircus*); *prong-horned antelope (*Antilocapra americana*); *roe deer (*Capreolus capreolus*); *bharal (*Ovis nahura*).

LOCATION.—Duodenum, more rarely stomach (fourth stomach of ruminants).

LOCALITIES COLLECTED.—North Africa, Europe, Japan, United States, ? India.

This species is so closely similar to *Strongylus colubriiformis* Giles, 1892, that it is very probable that the two are identical. Looss (1905o), however, considers that since there are certain discrepancies between Giles's (1892d, pp. 45-47, 49, figs. 1-9) description and figures on the one hand, and *Trichostrongylus instabilis* on the other, a further study of *Strongylus colubriiformis* will be necessary to settle the question as to whether the two forms are identical or not. In view of the fact, therefore, that Giles's description and figures of *Strongylus colubriiformis* in certain important respects do not correspond to *Trichostrongylus instabilis*, which may or may not be due to inaccuracies on the part of Giles, the name *Trichostrongylus instabilis* may be retained until more certain evidence as to the identity of the two forms can be procured.

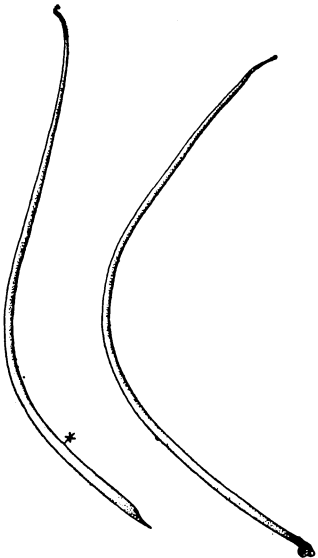


FIG. 94.—*Trichostrongylus instabilis*. Male at right, female at left. *Vulva. $\times 15$. (Original.)

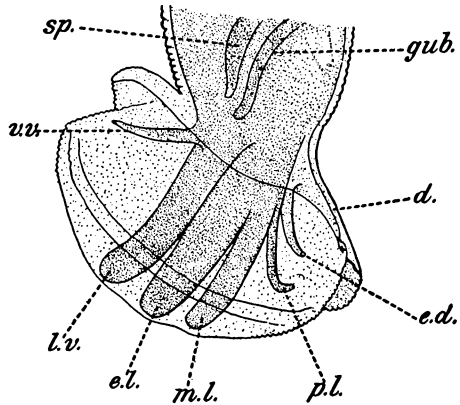


FIG. 95.—*Trichostrongylus instabilis*. Posterior end of body of male viewed from left side. *d.*, dorsal ray; *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *gub.*, gubernaculum; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *sp.*, portion of spicule; *v. v.*, ventro-ventral ray. $\times$ about 300. (After Looss, 19050, pl. 1, fig. 4.)

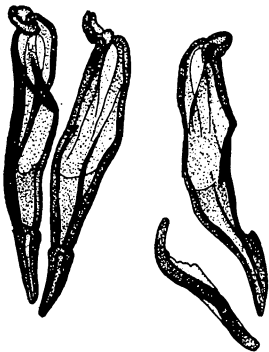


FIG. 96.—*Trichostrongylus instabilis*. Spicules and gubernaculum of male. Ventral view at left, lateral view at right. $\times$ about 300. (After Looss, 19050, pl. 1, fig. 6.)

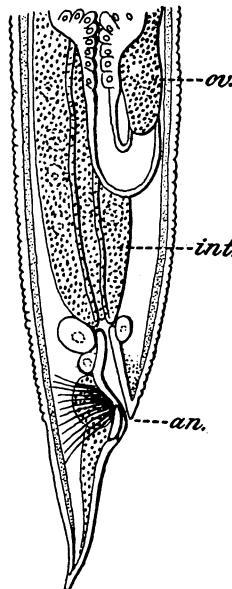


FIG. 97.—*Trichostrongylus instabilis*. Posterior end of body of female, viewed from right side. *an.*, anus; *int.*, intestine; *ov.*, ovary. $\times$ about 300. (After Looss, 19050, pl. 1, fig. 8.)

***Trichostrongylus colubriformis* (Giles, 1892) Ransom, 1911.**

1892: *Strongylus colubriformis* Giles, 1892c, p. 34; 1892d, pp. 45-47, 49, figs. 1-9 (in small intestine, *Ovis aries*, India).

1911: *Trichostrongylus colubriformis* (Giles) Ransom, 1911, pp. 14, 87, 90, 122 (the present paper).

SPECIFIC DIAGNOSIS.—*Trichostrongylus* (p. 86): Male nearly 6 mm. in length, 130 μ in thickness. Female about 8 mm. in length and of about the same thickness as the male. Body dark colored, the female usually straight, the male more usually contorted. Both sexes have the head extremely attenuated and become progressively thicker as the caudal extremity is approached; but while in the male the thickest part is quite at the caudal extremity, the female is thickest opposite the vulva, which is placed one-fifth of the entire body's length from the mucronate extremity of the tail. Mouth entire; quite unarmed. The female is provided with a pair of semielliptic alæ, situated opposite the neck which is markedly constricted, giving her the outline of a cobra.

Bursa of male deeply bilobed, the dorsal cleft being almost as deep as the ventral, so that the organ looks like a mussel shell, placed transversely, and attached to the worm at the hinge. Ventral costa small, the lateral and ventro-lateral costæ stout, subequal and forming a closely packed group; dorsal and dorso-lateral costæ small.

Ova (intra-uterine) elliptical, 90 μ long by 46 μ wide. A more advanced ovum, apparently mature, measured 110 μ . Vulva opens into the middle of a sort of cylindrical sac [ovijectors] which extends for a short distance forward and backward from the vaginal opening. The connection between the vagina and the uterine canals is effected by means of a thick chitinous, valvular apparatus, which closely resembles the esophageal bulb of certain nematodes, and, on high-power examination, is seen to be of a most complicated structure, the chitinous lining of the vagina projecting up into the end of the lax uterine canal and having a deeply sinuate margin. Surrounding this structure is a very thick muscular ring, which gives the bulb-like outline to the whole apparatus.

HOST.—Sheep (*Ovis aries*).

LOCATION.—Small intestine.

LOCALITY COLLECTED.—India.

The foregoing description is taken almost verbatim from Giles (1892d). *Trichostrongylus colubriformis* is very similar to if not identical with *T. instabilis* as already noted in the discussion of the latter species. The spicules of the former, as shown in Giles's figure 6, are exactly similar to those of *T. instabilis*, and, judging from the size of the figure and the scale of magnification, they have also the same length as the spicules of the latter species. Giles's drawing of the posterior end of the female also shows a great similarity to *T. instabilis*. The other drawings are less striking in their resemblance to *T. instabilis*, and some of them would not apply at all to this species unless it is assumed that they were inaccurately drawn.

***Trichostrongylus probolurus* (Railliet, 1896) Looss, 1905.**

(Figs. 98-101)

1896: *Strongylus probolurus* Railliet, 1896o, p. 542.

1905: *Trichostrongylus probolurus* (Railliet) Looss, 1905o, pp. 414, 417, 419-421, 422, pl. 2, figs. 9-11.

SPECIFIC DIAGNOSIS.—*Trichostrongylus* (p. 86): Male 4.5 to 5.5 mm. long and about 80μ wide at the beginning of the bursa. The latero-ventral ray (*l. v.*, fig. 99) is by far the widest of the rays (lateral view). The externo-lateral ray (*e. l.*, fig. 99) wider

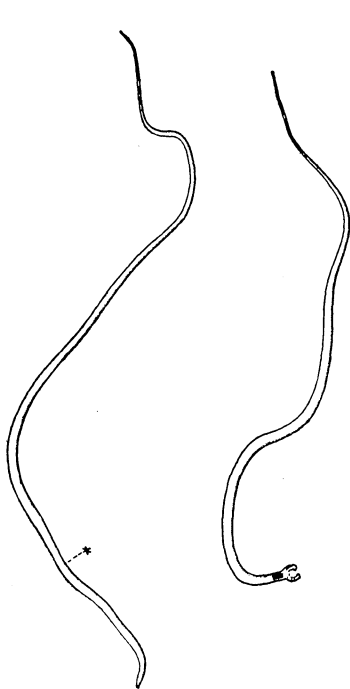


FIG. 98.—*Trichostrongylus probolurus*. Male at right, female at left. *Vulva. $\times 15$. (Original.)

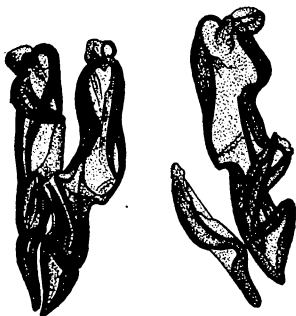


FIG. 100.—*Trichostrongylus probolurus*. Spicules and gubernaculum of male. Ventral view at left, lateral view at right. $\times$ about 300. (After Looss, 19050, pl. 2, fig. 10.)

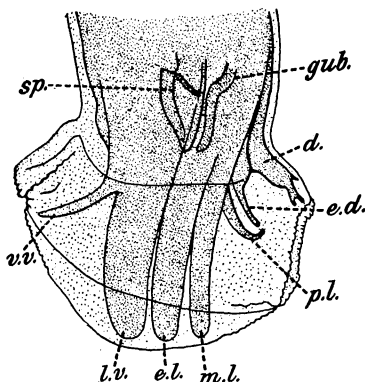


FIG. 99.—*Trichostrongylus probolurus*. Posterior end of body of male viewed from left side. *d.*, dorsal ray; *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *gub.*, portion of gubernaculum; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *sp.*, portion of spicule; *p. v.*, ventro-ventral ray. $\times$ about 300. (After Looss, 19050, pl. 2, fig. 9.)

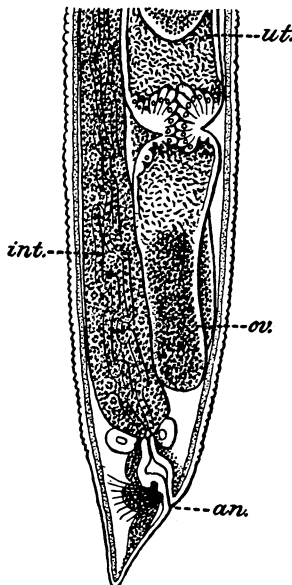


FIG. 101.—*Trichostrongylus probolurus*. Posterior end of body of female, viewed from right side. *an.*, anus; *int.*, intestine; *ov.*, ovary; *ut.*, uterus. $\times$ about 300. (After Looss, 19050, pl. 2, fig. 11.)

than the medio-lateral ray (*m. l.*, fig. 99). The postero-lateral (*p. l.*, fig. 99) and externo-dorsal (*e. d.*, fig. 99) rays are remarkably short and close together. The end of the former is turned back so far dorsally that the postero-lateral papilla on the inner

side of the bursa is directly opposite to or even somewhat dorsal of the externo-dorsal papilla upon the outer side of the bursa. Stem of the dorsal ray (*d.*, fig. 99) very short, divided as in *T. instabilis*. Spicules (fig. 100) 126 to 134 μ long and relatively thick. Gubernaculum 75 to 80 μ long, usually of a brilliant deep-brown color. Terminal hook of the spicule very high and sharply defined. In front of it on the ventral edge of the spicule is a second angular pointed projection, which together with the terminal hook when observed under low magnification, gives the spicule a gnarled or twisted appearance.

Female 4.5 to 6 mm. long and about 80 μ wide at the level of the vulva (1.08 to 1.25 mm. from the tail according to age). Posterior portion of the body (fig. 101) rather plump, becomes narrower beginning a very short distance in front of the anus, and rapidly diminishes in thickness, thus forming a short rather blunt tail, which commonly is turned diagonally upwards, or may be straight, or bent ventrally. Distance between tip of tail and anus (*an.*, fig. 101) 40 to 50 μ . Vulva including its chitinous border 76 μ long, elongated longitudinally, straight or slightly curved. Combined length of muscular portions of ovjectors including the sphincters about 375 μ . Eggs 76 to 80 μ long by 43 to 46 μ wide.

Hosts.—Sheep (*Ovis aries*); Dorcas gazelle (*Gazella dorcas*); man (*Homo sapiens*); Arabian camel (*Camelus dromedarius*); *Bactrian camel (*Camelus bactrianus*).

LOCATION.—Duodenum.

LOCALITIES COLLECTED.—North Africa, Europe, United States.

This species has been found but once in the United States, having been collected from a camel which died at the National Zoological Park, Washington, D. C.

Trichostrongylus vitrinus Looss, 1905.

(Figs. 102-105.)

1905: *Trichostrongylus vitrinus* Looss, 1905o, p. 421, pl. 2, figs. 12-14.

SPECIFIC DIAGNOSIS.—*Trichostrongylus* (p. 86): *Male* usually between 4 and 5.5 mm. long, and about 85 μ wide in front of bursa. Bursa (fig. 103) noticeably larger than in the other species of *Trichostrongylus* discussed in the present paper, the lateral lobes at their base being 140 to 180 μ broad in the dorso-ventral direction. Rays relatively more slender and straighter than in other species. The externo-lateral ray (*e. l.*, fig. 103) is the widest. Vento-ventral (*v. v.*, fig. 103) and postero-lateral (*p. l.*, fig. 103) rays of equal width, straight and reaching nearly to the edge of the bursa. Externo-dorsal ray (*e. d.*, fig. 103) short, its terminal papilla about halfway between the papilla of the postero-lateral ray and the middle of the dorsal ray. Unpaired portion of the latter (*d.*, fig. 103) relatively long, each of its branches usually ending in a simple point. Spicules (fig. 104) 160 to 170 μ long and gubernaculum 85 to 95 μ long, both of bright yellowish-brown color. The spicules end in a very sharp point, without definite hook-like projection.

Female usually between 5 and 6.5 mm. long, 84 to 92 μ wide at the level of the genital opening (1.15 to 1.25 mm. from the tip of the tail). Cuticle in the neighborhood of the vulva with irregular thickenings, absent or only slightly marked in young individuals, but always present in old ones. Vulva short, more or less crescentic, and usually placed diagonally to the axis of the body and raised a little above the level of the surface. Posterior end of the body (fig. 105) is noticeably narrowed behind the level of the loop of the posterior ovary (*ov.*, fig. 105), and then remains nearly cylindrical until the anus is reached, behind which it is reduced rapidly and symmetrically, so that the anus (*an.*, fig. 105) projects in a well marked angle. Tail (behind anus) usually bowed dorsalward. Combined length of muscular portions of ovjectors including the sphincters about 450 μ . Eggs 84 to 90 μ long by 46 to 50 μ wide.

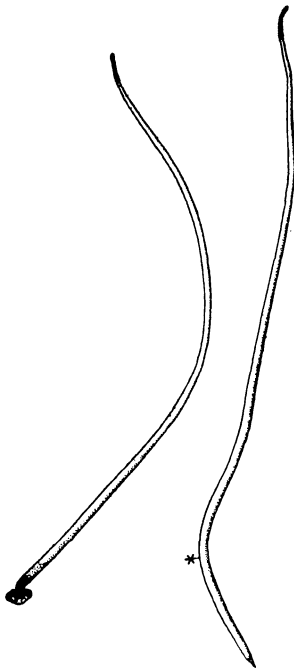


FIG. 102.—*Trichostrongylus vitrinus*. Male at left, female at right. *Vulva. $\times 15$. (Original.)

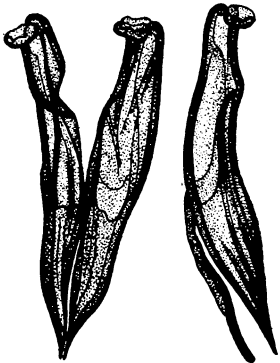


FIG. 104.—*Trichostrongylus vitrinus*. Spicules and gubernaculum of male. Ventral view at left, lateral view at right. $\times$ about 300. (After Looss, 1905o, pl. 2, fig. 13.)

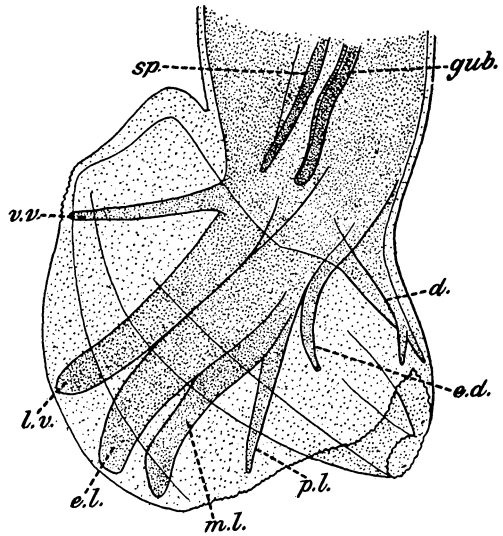


FIG. 103.—*Trichostrongylus vitrinus*. Posterior end of body of male viewed from left side. d., dorsal ray; e. d., externo-dorsal ray; e. l., externo-lateral ray; gub., portion of gubernaculum; l. v., latero-ventral ray; m. l., medio-lateral ray; p. l., postero-lateral ray; sp., portion of spicule; v. v., ventro-ventral ray. $\times$ about 300. (After Looss, 1905o, pl. 2, fig. 12.)

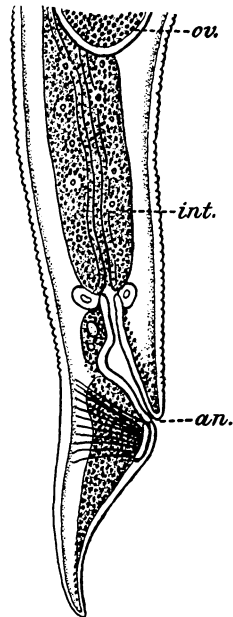


FIG. 105.—*Trichostrongylus vitrinus*. Posterior end of body of female, viewed from right side. an., anus; int., intestine; ov., ovary. $\times$ about 300. (After Looss, 1905o, pl. 2, fig. 14.)

HOSTS.—*Sheep (*Ovis aries*); Arabian camel (*Camelus dromedarius*); man (*Homo sapiens*); *goat (*Capra hircus*).

LOCATION.—Duodenum, and in ruminants occasionally in the fourth stomach.

LOCALITIES COLLECTED.—Europe, Africa, and United States.

This species has been found several times in small numbers in sheep and goats in the eastern United States, associated with other species of *Trichostrongylus*.

***Trichostrongylus extenuatus* (Railliet, 1898) Ransom, 1907.**

(Figs. 106–111.)

1896: *Strongylus gracilis* McFadyean, 1896b, pp. 319–320, pl. 4, figs. 6–8. (Not *Strongylus gracilis* F. S. Leuckart, 1842.)

1898: *Strongylus extenuatus* Railliet, 1898c, p. 254. (*S. gracilis* McFadyean 1896, renamed.)

1901: *Strongylus retortaeformis* Zeder of Stödter, 1901a, pp. 69, 75, 76, 77, 78, 79, 80, 81, 82, 84, 85, 92, 95, 96, pl. 11, figs. 6–8, pl. 12, figs. 1–12 (in part).

1907: *Trichostrongylus extenuatus* (Railliet, 1898) Ransom, 1907k, p. 2.

SPECIFIC DIAGNOSIS.—*Trichostrongylus* (p. 86): Male 3.4 to 4.4 mm. long by 50 to 60 μ thick in front of bursa. The ventro-ventral ray of the bursa (*v. v.*, figs. 107, 108) is very slender. The latero-ventral (*l. v.*, figs. 107, 108), externo-lateral (*e. l.*, figs. 107, 108) and medio-lateral (*m. l.*, figs. 107, 108) rays are of about equal thickness and the postero-lateral ray (*p. l.*, figs. 107, 108) slightly narrower. The latter is relatively much wider than in any of the other species of this genus occurring in ruminants, and also longer, extending nearly to the edge of the bursa. The externo-dorsal ray (*e. d.*, figs. 107, 108) is narrower and much shorter than the postero-lateral ray. Tips of the medio-lateral and postero-lateral rays closer together than those of any of the others. Dorsal ray (*d.*, figs. 107, 108) relatively long and slender, divided at the tip into two branches, each of which is also divided into two. Spicules (figs. 109, 110) yellowish-brown. An angular projection on the ventral surface of each spicule about 65 μ from the anterior end. Beyond this projection the right spicule terminates in a short point, the left spicule in a long slender point, usually somewhat crooked. The two spicules are thus dissimilar, the right spicule measuring 85 to 95 μ in length, the left spicule 110 to 120 μ . A slender, tapering, pointed, longitudinal process is given off from the inner side of each spicule near the middle. The gubernaculum (*gub.*, figs. 109, 110) is similar in color to the spicules and measures 50 to 60 μ in length. It usually lies dorsal of the right spicule in such a way as to give the latter the appearance on casual observation of terminating in a slender point like the left spicule.

Female 4.6 to 5.5 mm. in length by 55 to 70 μ in maximum thickness in the region of the vulva, which is located 0.8 to 1 mm. from the tip of the tail. Vulva 50 to 60 μ long, elongated longitudinally, with highly refractive chitinous lips. Posterior end of body (fig. 111) tapers gradually behind the loop of the posterior ovary (*ov.*, fig. 111) and more rapidly behind the anus (*an.*, fig. 111) which is located 60 to 90 μ from the tip of the tail. The tail is usually straight. Combined length of muscular portions of ovijectors 230 to 300 μ . The eggs measure 70 to 80 μ in length by 35 to 45 μ in width.

HOSTS.—*Cattle (*Bos taurus*); *sheep (*Ovis aries*); *goat (*Capra hircus*); *bharal (*Ovis nahuia*); *Mexican mountain sheep (*Ovis mexicana*); *prong-horned antelope (*Antilocapra americana*); *mule deer (*Odocoileus hemionus*); *roe deer (*Capreolus capreolus*); *Newfoundland caribou (*Rangifer terrænovæ*).

LOCATION.—Fourth stomach, more rarely anterior end of small intestine.

LOCALITIES COLLECTED.—United States, Australia, and Europe.

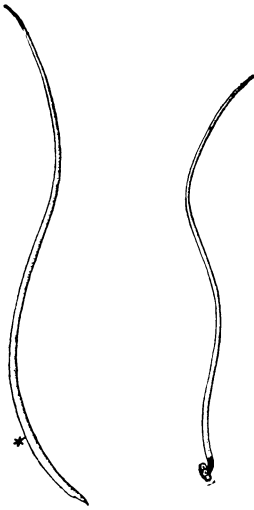


FIG. 106.—*Trichostrongylus extenuatus*. Male at right, female at left. *Vulva. $\times 15$. (Original.)

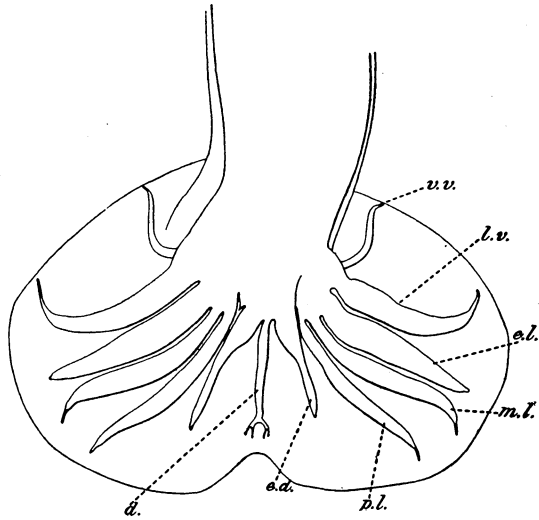


FIG. 107.—*Trichostrongylus extenuatus*. Bursa of male spread out. Dorsal view. *d.*, dorsal ray; *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *v. v.*, ventro-ventral ray. $\times 300$. (Original.)

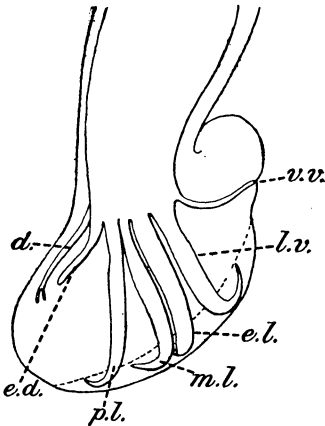


FIG. 108.—*Trichostrongylus extenuatus*. Bursa of male, viewed from right side. *d.*, dorsal ray; *e. d.*, externo-dorsal ray; *e. l.*, externo-lateral ray; *l. v.*, latero-ventral ray; *m. l.*, medio-lateral ray; *p. l.*, postero-lateral ray; *v. v.*, ventro-ventral ray. $\times 300$. (Original.)



FIG. 109.—*Trichostrongylus extenuatus*. Spicules and gubernaculum of male. Ventral view. *gub.*, gubernaculum. $\times 300$. (Original.)

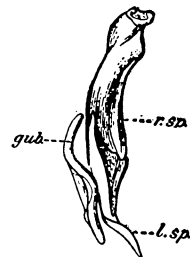


FIG. 110.—*Trichostrongylus extenuatus*. Spicules and gubernaculum of male, viewed from right side. *gub.*, gubernaculum; *l. sp.*, tip of left spicule; *r. sp.*, right spicule. $\times 300$. (Original.)

This is a common and widely distributed parasite of ruminants in the United States. It is considered by some authors to be a cause of gastro-enteritis in calves.

***Trichostrongylus capricola* Ransom, 1907.**

(Figs. 112-117.)

1907: *Trichostrongylus capricola* Ransom, 1907k, p. 2 (from *Capra hircus* and *Ovis aries*, United States).

SPECIFIC DIAGNOSIS.—*Trichostrongylus* (p. 86): Male 4.3 to 4.9 mm. long by 80 to 100 μ in maximum thickness a short distance in front of the bursa. The latero-ventral ray (l. v., figs. 113, 114) is the longest and thickest of the rays. Next in order of thickness is the externo-lateral (e. l., figs. 113, 114), then the medio-lateral (m. l., figs. 113, 114), then the postero-lateral ray (p. l., figs. 113, 114). The ventro-ventral (v. v., figs. 113, 114) and externo-dorsal (e. d., figs. 113, 114) rays are the slenderest, the latter however being considerably thickened proximally and in that region equal in thickness to the postero-lateral or even the medio-lateral ray. The branches of the dorsal ray (d., figs. 113, 114) are nearly equal in length to the stem, and are cleft at the end. The three lateral rays are nearly equal in length, shorter than the latero-ventral, and longer than the externo-dorsal ray. The tips of the lateral rays are separated by about equal intervals, these intervals being less than that between the tips of the postero-lateral and externo-dorsal rays, the latter interval in turn being less than that between the tips of the latero-ventral and externo-lateral rays. Spicules (figs. 115, 116) 130 to 145 μ long, gubernaculum (gub., figs. 115, 116) 75 to 80 μ long, all three yellowish-brown in color. The distal half or two-fifths of the spicule is about half as thick as the proximal portion and forms an angle of about 140 degrees with the latter, the convexity of the spicule being dorsal. The point of the spicule, less acute than in *Trichostrongylus vitrinus*, is as in the latter without the angular projection present in *T. instabilis*.

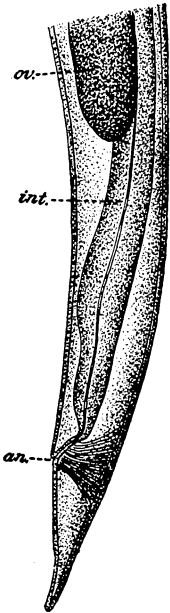


FIG. 111. — *Trichostrongylus extenuatus*. Posterior end of body of female, viewed from left side. an., anus; int., intestine; ov., ovary. $\times 300$. (Original.)

Female 5.8 to 6.8 mm. long by 75 to 80 μ in maximum diameter in the region of the vulva, which is located 1.1 to 1.4 mm. from the tip of the tail. Vulva a longitudinally elongated slit, slightly diagonal in position. It is covered over by one of the lips whose edge is reflected and fused with the cuticle of the body, except at one side, where a small circular opening is left. The chitin of the lips is delicate and usually inconspicuous. Length of vulva, including lips, 45 to 50 μ . The thickness of the body gradually decreases posteriorly to a size of 45 to 65 μ at the level of the loop of the posterior ovary (located 140 to 230 μ from the tip of the tail) and then undergoes a more rapid decrease to a size of 25 to 32 μ at the anus (an., fig. 117), which is situated, 60 to 80 μ from the tip of the tail. The ventral outline of the tail is slightly concave immediately behind the anus, then nearly straight to the tip; the dorsal outline usually describes a slightly convex curve from the anal region to the tip. Combined length of muscular portions of ovijectors, including the sphincters, 320 to 380 μ . The eggs measure 75 to 95 μ in length by 35 to 45 μ in width.

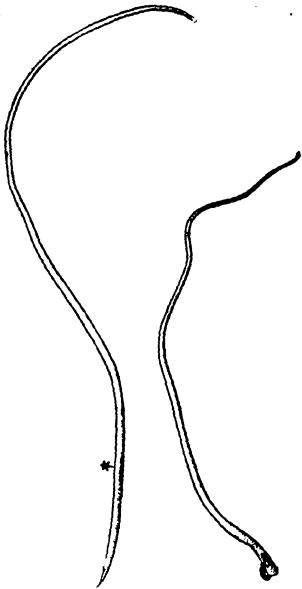


FIG. 112.—*Trichostrongylus capricola*. Male at right, female at left. * Vulva. $\times 15$. (Original.)

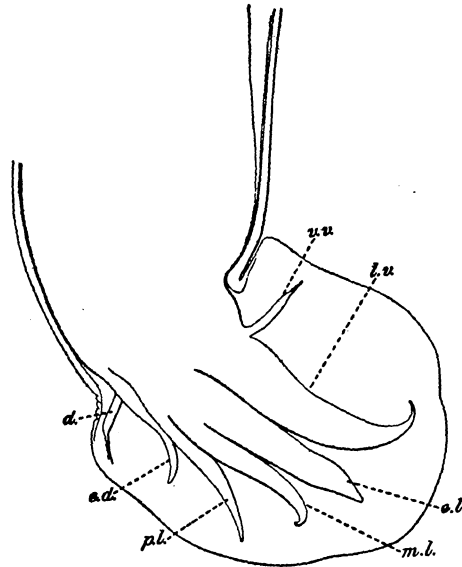


FIG. 114.—*Trichostrongylus capricola*. Bursa of male, viewed from right side. d., dorsal ray; e. d., externo-dorsal ray; e. l., externo-lateral ray; l. v., latero-ventral ray; m. l., medio-lateral ray; p. l., postero-lateral ray; v. v., ventro-ventral ray. $\times 300$. (Original.)

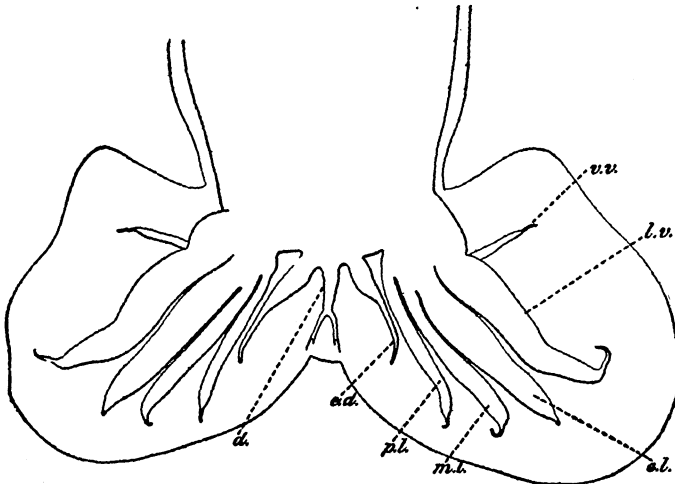


FIG. 113.—*Trichostrongylus capricola*. Bursa of male spread out d., dorsal ray; e. d., externo-dorsal ray; e. l., externo-lateral ray; l. v., latero-ventral ray; m. l., medio-lateral ray; p. l., postero-lateral ray; v. v., ventro-ventral ray. $\times 300$. (Original.)

HOSTS.—*Goat (*Capra hircus*); *sheep (*Ovis aries*); *prong-horned antelope (*Antilocapra americana*).

LOCATION.—Small intestine and fourth stomach.

LOCALITIES COLLECTED.—United States and Europe.

TYPE SPECIMENS.—Bureau of Animal Industry Helminthological Collection No. 14637, collected February 5, 1906, from the fourth stomach of a goat, at Bethesda, Md., by Dr. E. C. Stevenson.

This species has been frequently collected in this country from goats and sheep, more often from the former. Its presence in Europe is established by specimens in the collection of the Bureau of Animal Industry collected in France from a goat by Prof. A. Railliet.

SPECIES OF *METASTRONGYLINÆ* OF UNCERTAIN POSITION.

Strongylus ventricosus Rudolphi, 1809.

(Fig. 118.)

1809: *Strongylus ventricosus* Rudolphi, 1809a, pp. 222-223 (from *Cervus elaphus*, Europe).

SPECIFIC DIAGNOSIS.—*Metastrongylinæ* (p. 47) ? Genus: Head attenuate, with two small wings. Mouth terminal with unarmed border. Body capillary, in male increas-



FIG. 115.—*Trichostrongylus capricola*. Spicules and gubernaculum of male. Ventral view. *gub.*, gubernaculum. $\times 300$. (Original.)



FIG. 116.—*Trichostrongylus capricola*. Spicule and gubernaculum of male. Lateral view. *gub.*, gubernaculum. $\times 300$. (Original.)

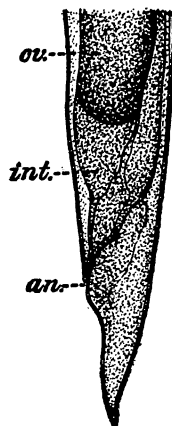


FIG. 117.—*Trichostrongylus capricola*. Posterior end of body of female, viewed from left side. *an.*, anus; *int.*, intestine; *ov.*, ovary. $\times 300$. (Original.)

ing in size backward, in female increasing in size forward and becoming very thick and ventricose at about the beginning of the third part, then again becoming slender.

Male 12 to 30 mm. long by 0.1 to 0.5 mm. thick. Tail with terminal copulatory bursa deeply incised ventrally. Bursa with five rays on each side, of which the anterior one is bifid. Spicules two, with short, thick recurved shanks, slightly twisted, canaliculate.

Female 16 to 30 mm. long by 0.2 to 0.5 mm. thick. Tail long, acutely conical, with rather obtuse apex. Anus remote from tip of tail. Vulva in posterior part of body.

HOST.—Stag (*Cervus elaphus*).

LOCATION.—Upper small intestine.

LOCALITY COLLECTED.—Greifswald, Germany.

The foregoing description of this species is taken from Molin (1861a, p. 515), who examined 3 males and 4 females not well preserved, apparently specimens upon which Rudolphi based his description. *Strongylus ventricosus* certainly does not belong in the genus *Strongylus*. Its proper generic position can not be determined at present.

The form from cattle which Schneider (1866a, pp. 144, 145) describes as *Strongylus ventricosus* Rudolphi is distinct from that described by Molin. The former is *Cooperia oncophora* (Railliet).

***Strongylus fordii* Daniels, 1908.**

1908: *Strongylus fordii* Daniels, 1908, Studies Inst. M. Research Fed. Malay States, Singapore, v. 3, pp. 15-16 (from *Bos taurus*, East Indies).

SPECIFIC DIAGNOSIS.—*Metastrongylinae* (p. 47), ? Genus: Anterior part of body for some 1 to 1.5 mm. is contracted and the cuticle somewhat thinner than elsewhere. Cervical papillæ not evident.

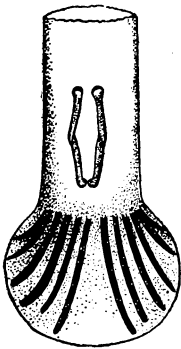


FIG. 118.—*Strongylus ventricosus*. Posterior end of body of male, showing bursa spread out, and spicules. Enlarged. (After Molin 1861a, pl. 28, fig. 8.)

Male 19 mm. long, 0.44 mm. broad, terminates in a bilobed caudal pouch, strengthened by ribs. The spicules, which are protruded between the lobes for a variable length, are continued in the interior, are distinctly tubular, and terminate in a trumpet-shaped expansion. They are equal, and the total length is 6.2 mm., or more than one-fourth the length of the body.

Female 21 mm. in length, greatest breadth 0.5 mm. The mouth is terminal and the cuticle surrounding it is thickened, so as to form a circle of small rounded projections. The esophagus, 1.9 mm. in length, is thick, muscular, and ends in a slight dilation before the marked junction with the intestine. Anus close to the sharp-pointed tail. Ovarian tubes double, not twisted round the intestine as in *Hæmonchus contortus*, and end in a long thin-walled vagina, in which a single row of eggs is contained.

The genital opening is marked by no protecting fold and is situated 0.5 to 0.6 mm. from the tip of the tail.

HOST.—Cattle (*Bos taurus*).

LOCATION.—Stomach or intestine.

LOCALITY COLLECTED.—East Indies.

The description given by Daniels, on which the foregoing diagnosis is based, is too imperfect to properly place this species generically. It evidently, however, does not belong in the genus *Strongylus*.

FAMILY FILARIIDÆ CLAUS, 1885.

FAMILY DIAGNOSIS.—Nematoda: Body long, filiform. Mouth surrounded with papillæ, or provided with two lips. Esophagus slender, without posterior bulb. Males with a single spicule or with two unequal spicules. Females with two ovaries; vulva usually in front of the middle of the body. Usually ovo-viviparous. Development in many cases requires an intermediate host.

TYPE GENUS.—*Filaria* Müller, 1787.

Two genera of this family are represented among the nematodes parasitic in the alimentary tract of ruminants.

KEY TO GENERA OF FILARIIDÆ.

Anterior portion of body covered with numerous cuticular tubercles or shields; vulva of female in posterior portion of body, a short distance in front of anus; male 30 to 50 mm. long, female 70 to 145 mm. long.....*Gongylonema*, p. 100

Anterior portion of body without cuticular tubercles; vulva of female in anterior portion of body; male 9 to 13 mm. long, female 12 to 26 mm. long.

Spiroptera, p. 103

Genus GONGYLONEMA Molin, 1857.

1857: *Gongylonema* Molin, 1857a, pp. 148-152, 216-223.

1892: *Myzomimus* Stiles, 1892b, pp. 65-67 (type species, *M. scutatus* (Mueller, 1869) Stiles, 1892).

GENERIC DIAGNOSIS.—Filariidæ (p. 99): Body filiform, slightly attenuated toward the two extremities. Cuticle transversely striated. Mouth small, elongated dorso-ventrally, surrounded by six small papillæ. Anterior portion of body covered with numerous tubercles or shields formed by differentiation of the cuticle. In the median lines immediately behind the mouth, two semilunar depressions simulating suckers, one dorsal and one ventral. A short distance behind the mouth two cervical papillæ, one in each lateral line. Esophagus consists of two distinct portions, a slender anterior portion, and a thicker posterior portion. Tail of male curved ventrally, supplied with two asymmetrical membranous wings, supported by elongated, claviform papillæ, mostly arranged in pairs, some preanal and some postanal. Two unequal spicules, one short, one very long. Vulva of female situated a short distance in front of anus. Eggs ellipsoidal, containing vermiform embryos when deposited.

TYPE SPECIES.—*Gongylonema minimum* Molin, 1857.

Two species of this genus are found in the alimentary tract of ruminants.

KEY TO SPECIES OF GONGYLONEMA.

A membranous wing along the dorsal median line in the anterior portion of the body; cuticular tubercles lacking on ventral surface of female; tail of female suddenly diminished in size behind the anus; male 35 to 40 mm. long, female 70 to 90 mm. long.....*Gongylonema verrucosum*, p. 102

Dorsal median line without longitudinal membranous wing; cuticular tubercles present on ventral surface of female; tail of female gradually diminished in size behind the anus; male 30 to 50 mm. long, female 80 to 145 mm. long.

Gongylonema scutatum, p. 100

***Gongylonema scutatum* (Mueller, 1869) Railliet, 1892.**

(Figs. 119-122.)

1869: *Spiroptera scutata* F. Mueller, 1869a, pp. 127-129.

1873: *Filaria scutata* Leuckart, 1873b, p. 557.

1892: *Myzomimus scutatus* (Mueller) Stiles, 1892b, pp. 65-67, 1 fig.

1892: *Gongylonema scutatum* (Mueller) Railliet, 1892e, pp. 694-696.

SPECIFIC DIAGNOSIS.—*Gongylonema* (p. 100): Cuticular tubercles present in the anterior 1 to 3 mm. of the body, rounded or oval, arranged more or less regularly in two rows in each of the four submedian fields (fig. 119). On the ventral surface surrounding the excretory pore, some of the tubercles of the four ventral rows are commonly fused into a single plate. Along each lateral line, behind the cervical papillæ, a membranous wing which terminates at about the posterior limits of the cuticular tubercles. Mouth oblong, with two lateral and four smaller submedian papillæ.

Male 30 to 50 mm. long by about 250μ thick. Tail (figs. 121, 122) slightly twisted on its axis, as a result of the arrangement of the asymmetrical bursal wings. The right wing is nearly parallel to the median plane of the body, widest at a point a little behind the level of the anus, terminating slightly in front of the tip of the tail toward its dorsal surface. A supplementary wing begins on the right side on the dorsal surface near the tip of the tail, and passes around the latter. The left wing follows a slightly twisted course, beginning on the dorsal surface and extends to the tip of the tail which it surrounds. The left wing is shorter than the right and its maximum width is less. On its inner surface in its posterior portion there are frequently found supplementary lobes with undulating borders. Each wing is supported by 5 or 6 preanal papillæ and 5 to 7 postanal papillæ, usually asymmetrical in arrangement. Left spicule 16 to 17 mm. long; right spicule 140 to 180μ long.

Female 80 to 145 mm. long by 300 to 350μ thick. Vulva 4 to 5

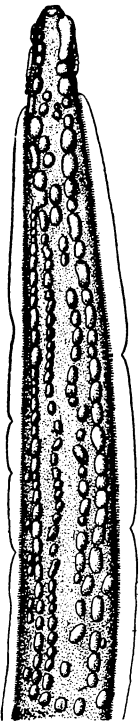


FIG. 119.—*Gongylonema scutatum*. Anterior end of body. Dorsal view. $\times 45$. (After Neumann, 1894d., fig. 1.)

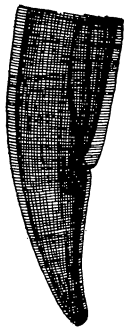


FIG. 120.—*Gongylonema scutatum*. Posterior end of body of female, viewed from right side. $\times 65$. (After Neumann, 1894d., fig. 2—1.)

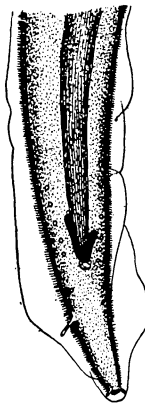


FIG. 121.—*Gongylonema scutatum*. Posterior end of body of male. Ventral view. $\times 65$. (After Neumann, 1894d., fig. 2—2.)

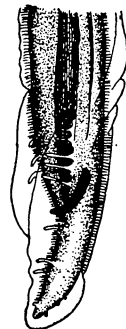


FIG. 122.—*Gongylonema scutatum*. Posterior end of body of male, viewed obliquely from left side. $\times 65$. (After Neumann, 1894d., fig. 2—2g.)

mm. from the tip of the tail. Eggs 55 to 60μ long by 32 to 36μ wide. Embryos provided with a buccal stylet.

Hosts.—*Cattle (*Bos taurus*); *sheep (*Ovis aries*); goat (*Capra hircus*); zebu (*Bos indicus*).

LOCATION.—In burrows in the lining mucosa of the esophagus and pharynx, occasionally free in the lumen of the paunch.

LOCALITIES COLLECTED.—Europe, United States, India, North Africa, Australia.

This is a very common species in this country and is seen in a large percentage of cattle and sheep slaughtered at abattoirs. It has been frequently observed in Europe and Africa, and probably is distributed throughout most of the world. It has been reported from a horse by Müller (1869a). *Gongylonema scutatum* has no apparent effect on the health of animals which it infests. Its only economic importance so far as recognized is in rendering the esophagus undesirable for use in meat food products.

Gongylonema verrucosum (Giles, 1892) Neumann, 1894.

(Figs. 123-125.)

1892: *Trichosomum verrucosum* Giles, 1892d, pp. 47-48.1892: *Spiroptera verrucosa* Giles, 1892d, Addendum (not *Spiroptera verrucosa* Molin, 1860).1894: *Gongylonema verrucosum* (Giles) Neumann, 1894d, pp. 470-472, fig. 4.1898: *Gongylonema crenatum* Railliet, 1898b, p. 173 (*G. verrucosum* renamed).

SPECIFIC DIAGNOSIS.—*Gongylonema* (p. 100): Cuticular tubercles, large, rather widely separated, striated transversely, lacking on the ventral surface in the female, forming two or three irregular longitudinal rows 3 mm. long on each side of the median line on the dorsal surface (fig. 123). In the anterior portion of the body a narrow festooned membranous wing along each lateral line, and a deeply and regularly festooned wing along the dorsal median line. Cervical papillæ small. Mouth surrounded by six papillæ.

Male 35 to 40 mm. long by 250 to 300 μ thick. Five or six pairs of preanal and five pairs of postanal papillæ (fig. 124). Right bursal wing shorter and much narrower than the left,

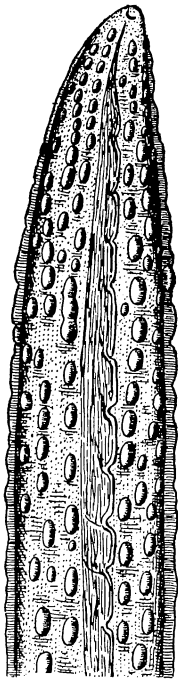


FIG. 123.—*Gongylonema verrucosum*. Anterior end of body. Dorsal view. $\times 57$. (After Neumann, 1894d, fig. 4-1.)

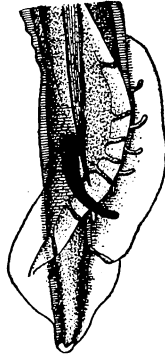


FIG. 124.—*Gongylonema verrucosum*. Posterior end of body of male, viewed obliquely. $\times 65$. (After Neumann, 1894d, fig. 4-2.)

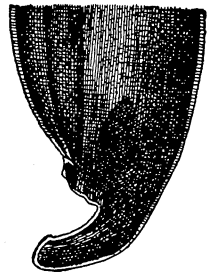


FIG. 125.—*Gongylonema verrucosum*. Posterior end of body of female, viewed from left side. $\times 60$. (After Neumann, 1894d, fig. 4-3.)

terminating posteriorly some distance from the tip of the tail, where it is replaced by a supplementary wing, dorsal in origin. Left bursal wing wide and prolonged to the tip of the tail. Left spicule about 10 mm. long; right spicule about 300 μ long.

Female 70 to 90 mm. long by 420 to 460 μ in thickness. Vulva 1.2 mm. to 3.2 mm. from the tip of the tail. Behind the anus the tail (fig. 125) is abruptly diminished in thickness, forming a terminal appendage 0.2 mm. long, provided with a median ventral papilla. Eggs 45 to 50 μ long by 25 to 27 μ wide.

HOSTS.—Zebu (*Bos indicus*); sheep (*Ovis aries*).

LOCATION.—Stomach, free in the lumen or in galleries which the parasite burrows in the mucosa.

LOCALITY COLLECTED.—India.

This species has not yet been reported from the United States. The foregoing diagnosis is based on Neumann's (1894d) description.

Genus *SPIROPTERA* Rudolphi, 1819.

1811: *Acuaria* Bremser, 1811a, p. 26 (type species, *Spiroptera anthuris*, established by Rudolphi 1819a, p. 244).

1819: *Spiroptera* Rudolphi, 1819a, pp. 22-29, 235-255 (*Acuaria* renamed).

1819: *Anthuris* Rudolphi, 1819a, p. 244 (*Acuaria* renamed).

1845: *Dispharagus* Dujardin, 1845a, pp. 42, 69-82 (type species, *Spiroptera anthuris*).

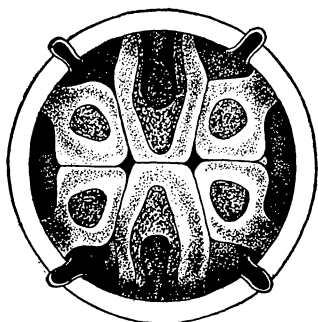


FIG. 126.—*Spiroptera verrucosa*. Head. Anterior view. $\times 280$. (After Drasche, 1884a, pl. 11, fig. 18.)

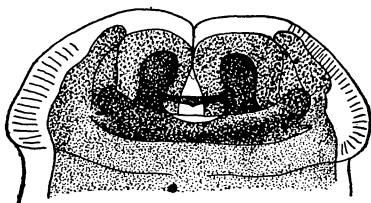


FIG. 127.—*Spiroptera verrucosa*. Head. Median view. $\times 280$. (After Drasche, 1884a, pl. 11, fig. 19.)

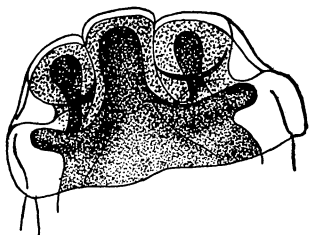


FIG. 128.—*Spiroptera verrucosa*. Head. Lateral view. $\times 280$. (After Drasche, 1884a, pl. 11, fig. 20.)

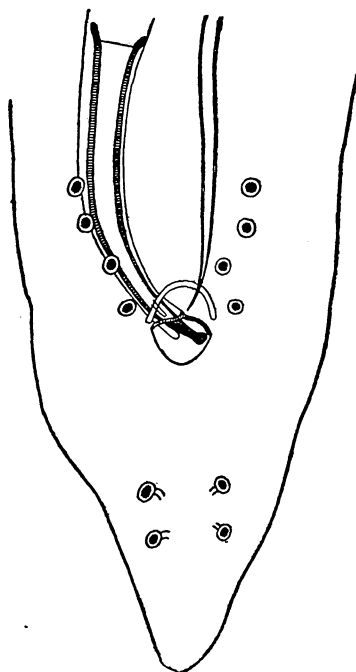


FIG. 129.—*Spiroptera verrucosa*. Posterior end of body of male. Ventral view. $\times 120$. (After Drasche, 1884a, pl. 13, fig. 1.)

Spiroptera (or more properly *Acuaria*) is commonly included in the family Filaridiæ. As it is probable that *Spiroptera verrucosa* (the only species of the genus to be considered in the present paper) does not belong in the genus *Spiroptera*, and as the characters of the genus are very imperfectly known, I have not attempted to formulate a generic diagnosis.

The name *Spiroptera* is an absolute synonym of the earlier *Acuaria*, but I have retained the former name in the present paper in order to avoid adding to the synonymy of *Spiroptera verrucosa*.

KEY TO SPECIES OF SPIROPTERA.

One species in ruminants.....*Spiroptera verrucosa*, p. 104

***Spiroptera verrucosa* Molin, 1860.**

(Figs. 126-129.)

1860: *Spiroptera verrucosa* Molin, 1860b, pp. 964-965 (from *Cervus nambi* [= *Mazama nana*] and *Cervus dichotomus* [= *Blastocerus paludosus*], Brazil).

1897: *Filaria verrucosa* (Molin, 1860) Stossich, 1897b, pp. 53-54 (*S. verrucosa* Molin, renamed).

SPECIFIC DIAGNOSIS.—*Spiroptera* (p. 103): Anterior end of body scarcely attenuated with rotund apex. Head (figs. 126-128) distinct from rest of body, provided with two large lateral lips, each of which is subdivided into three parts by two deep furrows. The lips meet in a straight dorso-ventral median line. Four large conical submedian papillæ at the base of the lips. Cuticle of body densely striated transversely. Two longitudinal lateral wings.

Male 9 to 13 mm. long by 0.3 mm. thick. Tail (fig. 129) obtusely pointed, curled spirally in one or two turns, with conspicuous lateral wings. Four pairs of large preanal papillæ and two pairs of postanal papillæ. A semilunar thickening of the cuticle in front of the anus. Right spicule thick, curved, blunt, about 375 μ long; left spicule filiform, acutely pointed, alate, and about five times as long as the right.

Female 12 to 26 mm. long by 0.4 to 0.6 mm. thick. Tail curved, with obtuse apex. Anus not far from the tip of the tail. Vulva in anterior portion of body.

HOSTS.—Pygmy brocket (*Mazama nana*); marsh deer (*Blastocerus paludosus*).

LOCATION.—Stomach.

LOCALITY COLLECTED.—Brazil.

The foregoing diagnosis is based upon the original description by Molin (1860b) and the description and figures given by Drasche (1884a, p. 203, pl. 11, figs. 18-20, pl. 13, fig. 1), who reexamined Molin's specimens.

FAMILY ANGIOSTOMIDÆ Braun, 1895.

FAMILY DIAGNOSIS.—Nematoda: Two heterogenetic generations, one of free-living males and females and one of hermaphroditic or parthenogenetic forms, which are parasitic.

TYPE GENUS.—*Angiostoma* Dujardin, 1845.

KEY TO GENERA OF ANGIOSTOMIDÆ.

One genus in ruminants.....*Strongyloides*, p. 104

Genus STRONGYLOIDES Grassi, 1879.

1879: *Strongyloides* Grassi, 1879f, p. 497.

1879: *Strongyloides* Grassi, 1879e, p. 233.

1881: *Pseudo-rhabditis* Perroncito, 1881w, pp. 499-519.

GENERIC DIAGNOSIS.—*Angiostomidæ* (p. 104): Parasitic form with mouth opening directly into the relatively very long subcylindrical esophagus. Mouth surrounded by (?six) small papillæ. Cuticle finely striated transversely. Vulva posterior of the middle of the body. Uterus double. Two ovaries. Eggs ellipsoidal with thin shells. Free-

living form with mouth opening into a vestibule or pharynx, followed by an esophagus whose anterior portion is fusiform and posterior portion globular. The posterior bulb of the esophagus of the free-living form is furnished with a toothed masticatory apparatus. Free-living male with two short spicules of equal size.

TYPE SPECIES.—*Strongyloides intestinalis* (Bavay, 1877) Grassi, 1879=*S. stercoralis* (Bavay, 1876).

Two species of this genus are found in ruminants.

KEY TO SPECIES OF STRONGYLOIDES.

Anus 55 to 70 μ from the tip of the tail; eggs deposited singly, not inclosed in sacs.

Strongyloides papillosus, p. 105

Anus 45 to 50 μ from the tip of the tail; eggs after passing out of the vulva lodge beneath an outer cuticular layer, which when shed by the worm forms egg-sacs, each containing from half a dozen to 50 or more eggs. *Strongyloides ovocinctus*, p. 108

***Strongyloides papillosus* (Wedl, 1856), Ransom, 1911.**

(Figs. 130-133.)

1856: *Trichosoma papillosum* Wedl, 1856b, pp. 129-130, figs. 13-14.

1887: *Rhabdonema longus* Grassi and Segrè, 1887a, p. 107.

1888: *Strongyloides longus* (Grassi and Segrè) Rovelli, 1888.

1911: *Strongyloides papillosus* (Wedl) Ransom, 1911, pp. 15, 105-108, 109, 110, 121, 122, figs. 130-133 (the present paper).

SPECIFIC DIAGNOSIS.—*Strongyloides* (p. 104): *Parasitic generation*. Length 3.5 to 6 mm., thickness 50 to 60 μ . Body (fig. 130) filiform, of nearly equal thickness throughout most of its length, gradually attenuated anteriorly to a diameter of about 15 μ at the head. Posterior end of body (fig. 132) diminished in size backward beginning some distance in front of the anus near the loop of the posterior ovary (ov., fig. 132), then suddenly reduced just behind the anus, and terminating in a short slightly tapering tail with rounded tip. Esophagus increases gradually in size posteriorly, and is 650 to 800 μ long. Diameter of body at base of esophagus 40 to 45 μ . Anus (an., fig. 132) 55 to 70 μ from the tip of the tail. Diameter of body at anus about 20 μ . Vulva (vul., fig. 131) a transverse slit with rather salient lips situated 1.6 to 2 mm. from the posterior end of the body. Eggs (e., fig. 131) ellipsoidal with very thin shells, 40 by 20 μ to 60 by 25 μ in diameter. Not more than a dozen or fifteen fully formed eggs present in the two uteri at any one time. Eggs of this species when passed in the feces of the host usually contain vermiform embryos which hatch in a few hours under suitable conditions of temperature.

Free-living generation. *Male* undescribed. *Female* (fig. 133) 1 to 1.2 mm. long by 40 μ in thickness. Esophagus $\frac{1}{7}$ to $\frac{1}{4}$ the total length of the body. Vulva (vul., fig. 133) with salient lips near the middle of the body. Tail slender, acutely pointed. Anus (an., fig. 133) about $\frac{1}{7}$ the length of the body from the posterior end. Eggs (e., fig. 133) 65 by 30 μ in diameter.

HOSTS.—*Sheep (*Ovis aries*); *goat (*Capra hircus*); *rabbit (*Lepus cuniculus*); also reported from other rodents.

LOCATION.—Small intestine.

LOCALITIES COLLECTED.—Europe, United States, ? South America.

Wedl (1856b) found in the intestine of a sheep rather numerous specimens of hair-like worms which he described under the name of *Trichosoma papillosum*. He remarks that only females were present. His description translated is as follows:

Length 5 mm. Anterior portion of body attenuated, head 16 μ broad. In posterior portion of body the breadth increases to 55 μ . Tail terminating in a bluntly pointed

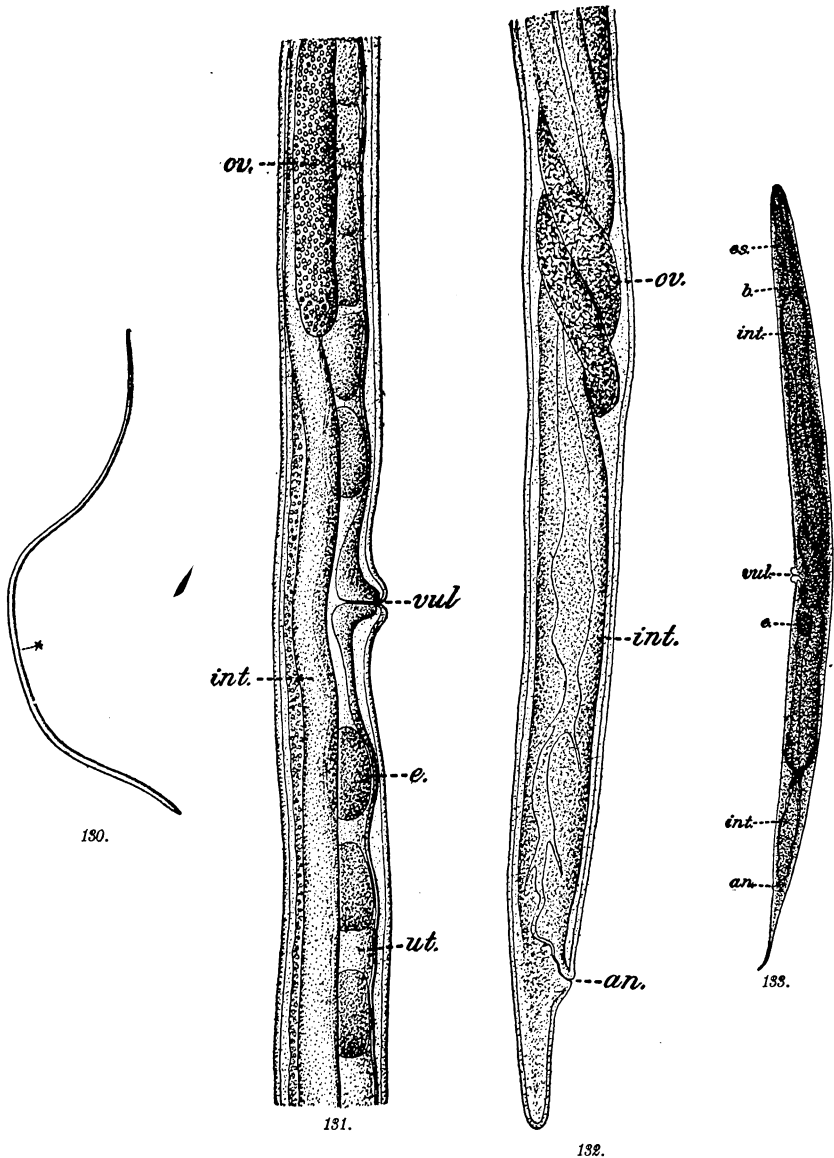


FIG. 130.—*Strongyloides papillosus*. Parasitic adult. * Vulva. $\times 15$. (Original.)
 FIG. 131.—*Strongyloides papillosus*. Portion of body of parasitic adult in region of vulva, viewed from right side. e., egg; int., intestine; ov., ovary; ut., uterus; vul., vulva. $\times 300$. (Original.)
 FIG. 132.—*Strongyloides papillosus*. Posterior end of body of parasitic adult, viewed from right side. an., anus; int., intestine; ov., ovary. $\times 300$. (Original.)
 FIG. 133.—*Strongyloides papillosus*. Female of free-living generation, viewed from left side. an., anus; b., posterior bulb of esophagus; e., egg in uterus; es., esophagus; int., intestine; vul., vulva. $\times 100$. (Original.)

conical tip. Head supplied with 4 well marked papillæ. Esophagus very long, presenting a well marked line which indicates its lumen. The relatively large vulva is situated at the beginning of the posterior third of the body, its position indicated by a slightly projecting papilla. Uterus bicornate, not infrequently evaginated through the vulva. Eggs arranged in uterus in a single row, or may be shoved together so that one lies over another. Eggs ellipsoidal, thin-shelled, 48 to 52 μ long by 28 μ broad. Ovaries much twisted, wound spirally around the intestine.

Curtice (1890c) was of the opinion that *Trichosoma papillosum* should be united with *Strongylus filicollis* (= *Nematodirus filicollis*), remarking that Wedl's species was certainly not a trichosome since it possesses a double uterus. Railliet (1893a, p. 489) notes that the difference in the size of the eggs precludes the possibility of *Trichosoma papillosum* and *Strongylus filicollis* being the same, and he considers Wedl's species to be a strongyle.

Wedl's description and figures correspond perfectly, however, with *Strongyloides longus* (Grassi and Segrè) and there can be little doubt that *Trichosoma papillosum* and *Strongyloides longus* are one and the same species, which under the rules of nomenclature takes the name *Strongyloides papillosus*.

Strongyloides papillosus is an interesting example of a nematode in whose life-cycle there may be two generations of dissimilar individuals, one generation parasitic and the other free-living. The parasitic generation consists entirely of parthenogenetic females, from whose eggs hatch embryos which may either develop into free-living males and females or transform into filariform larvæ. As pointed out in a former paper (Ransom, 1907k) the latter develop into the parthenogenetic parasitic forms if taken into the body of a suitable host, infection occurring either by way of the mouth or through the skin, which the larvæ may penetrate and finally reach the intestine, presumably following a course similar to that taken by larval hook-worms when they enter the body through the skin, that is, by way of the blood vessels, heart, lungs, trachea, pharynx, esophagus, and stomach.

In the event of the development of embryos produced by the parthenogenetic forms into free-living adults it has been found, as in the case of *Strongyloides stercoralis*, that from these come embryos which transform into filariform larvæ resembling those which develop directly from the parasitic generation. The life-cycle may therefore include in the following order, first, parthenogenetic parasitic forms; second, free-living rhabditiform embryos (newly hatched embryos whose esophagus is swollen posteriorly into a bulb containing a masticatory apparatus); and, third, free-living filariform larvæ (with esophagus similar to the parasitic adult); or, first, parthenogenetic parasitic forms; second, free-living rhabditiform embryos; third, free-living males and females, from which come free-living rhabditiform

embryos and these in turn transform into free-living filariform larvæ, the filariform larvæ in both cases developing into the parasitic parthenogenetic adults when taken into the body of a suitable host.

Strongyloides papillosus may occur in sheep in enormous numbers, but it is questionable whether it has any serious effects upon the health of infested animals. On superficial examination this parasite is likely to be confused with the females of a species already considered, *Trichostrongylus extenuatus*. It has been commonly met with in sheep and goats at the Bureau of Animal Industry Experiment Station, Bethesda, Md., and has been reared experimentally (Ransom, 1907k) in rabbits by feeding larvæ and by placing larvæ on the skin. It has been recorded by different observers as a parasite of sheep and rabbits in Europe. The parasite of the pig which has been identified as *Strongyloides longus* (= *S. papillosus*) by European observers is probably *Strongyloides suis*. This species has been found a number of times in pigs at the Bureau of Animal Industry Experiment Station, Bethesda, Md.

***Strongyloides ovocinctus* Ransom, 1911.**

(Figs. 134-137.)

1911: *Strongyloides ovocinctus*, Ransom 1911, pp. 15, 18, 23, 105, 108-110, 112, 122, figs. 134-137 (the present paper).

SPECIFIC DIAGNOSIS.—*Strongyloides* (p. 104): *Parasitic generation*. Length 4.5 to 5 mm., thickness 40 to 50 μ . Body (fig. 134) filiform of nearly equal thickness throughout its length, gradually attenuated anteriorly to a diameter of about 15 μ at the head. Posterior end of body diminished in size backward, beginning some distance in front of the anus near the loop of the posterior ovary, then suddenly reduced just behind the anus, and terminating in a short, slightly tapering tail with rounded tip (fig. 136). Esophagus increases in size posteriorly, 600 to 750 μ long. Diameter of body at base of esophagus 40 to 45 μ . Anus (*an.*, fig. 136) 45 to 50 μ from the tip of the tail. Diameter of body at anus about 20 μ . Vulva (*vul.*, fig. 135) a transverse slit with rather salient lips, situated 1.6 to 2 mm. from the tip of the tail. Eggs (*e.*, figs. 135, 136) ellipsoidal with very thin shells, 45 by 30 μ to 50 by 25 μ in diameter. Not over 25 fully formed eggs in the two uteri at any one time. Adult worms apparently undergo successive molts. The eggs passing out of the vulva lodge beneath an outer cuticular layer (*cut.*, figs. 135, 136), which when finally shed by the worm is transformed into elongated egg sacs (fig. 137), each containing from half a dozen to 50 or more eggs.

Free-living generation. Unknown.

HOST.—*Prong-horned antelope (*Antilocapra americana*).

LOCATION.—Intestine.

LOCALITY COLLECTED.—United States.

TYPE SPECIMENS.—Bureau of Animal Industry Helminthological Collection No. 1947, collected August 13, 1892, at Washington, D. C., by Dr. Albert Hassall.

Were it not for the remarkable manner in which *Strongyloides ovocinctus* deposits its eggs this species could be scarcely distinguished from *Strongyloides papillosus*. Both species are of practically the same size; the general form of the body is the same in both; the esophagus is of similar shape and size; the vulva is located in the

same region of the body; and the tail has the same shape in both species. In *S. papillosus* the tail is generally somewhat longer than has been noted in *S. ovocinctus*, 55 to 70 μ as compared with 45 to 50 μ . The eggs also appear to average larger, 40 to 60 μ in length in the former, as compared with 45 to 50 μ in the latter. Another difference is in the maximum number of fully formed eggs which may be present

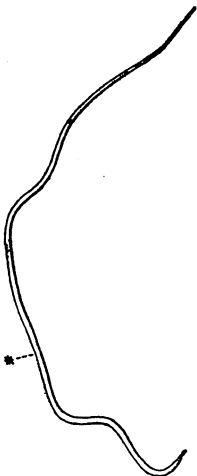


FIG. 134.—*Strongyloides ovocinctus*. Parasitic adult. *Vulva. $\times 15$. (Original.)

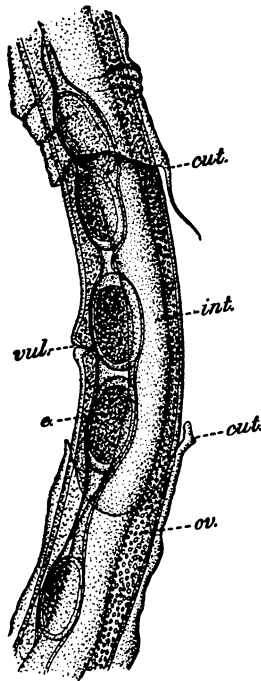


FIG. 135.—*Strongyloides ovocinctus*. Portion of body of parasitic adult in region of vulva, viewed from left side. *cut.*, outer cuticular layer; *e.*, egg; *int.*, intestine; *ov.*, ovary; *vul.*, vulva. $\times 300$. (Original.)

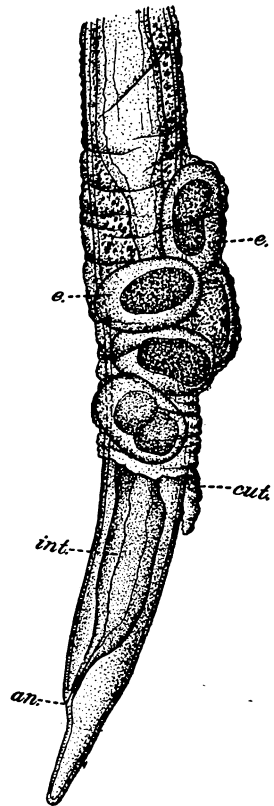


FIG. 136.—*Strongyloides ovocinctus*. Posterior end of body of parasitic adult, viewed from left side. *an.*, anus; *cut.*, outer cuticular layer; *e.*, eggs lodged beneath the outer loosened cuticle; *int.*, intestine. $\times 300$. (Original.)

in the uteri, not more than 15 having been observed in *S. papillosus*, whereas in *S. ovocinctus* as many as 25 have been counted. These differences, however, are of minor importance in view of the possibility that an examination of a large number of specimens of both species would demonstrate the occurrence of individual variations with a range wide enough to obliterate the apparent differences just enumerated. Hence the only important differences thus far recog-

nized in the two species is in the method of oviposition, and even here the possibility is not excluded that this is only an apparent and not a real difference, and that it is simply due to an imperfect knowledge of *S. papillosus*. However, I have examined a considerable number of specimens of *S. papillosus* without finding any evidence of the occurrence of the peculiar method of oviposition characteristic of *S. ovocinctus*, and it therefore seems advisable for the present to recognize two distinct species.

It should be noted as of interest in the present connection that Brumpt (1910, Précis de parasitologie, p. 431, fig. 270) has mentioned the occurrence of strings of *Strongyloides* eggs in the feces of sheep. He interprets the sheath surrounding the string of eggs as the body of a dead worm or its uterus. Evidently these strings of eggs are the result of a process of oviposition similar to that occurring in *Strongyloides ovocinctus*. Whether the *Strongyloides* in question was *S. ovocinctus*, *S. papillosus*, or another species is uncertain. Looss (1905, Handbuch d. Tropenkrankh. [Mense], v. 1, p. 189) states with reference to *S. stercoralis* that this species, which normally deposits its eggs in the burrows which it forms in the intestinal mucosa, may when wandering free in the lumen of the intestine deposit its eggs in short strings. Looss, however, gives no description of these strings or eggs, nor does he offer an explanation of the way in which they are formed. It is very probable that the strings of eggs deposited by *S. stercoralis* originate in the same manner as those deposited by *S. ovocinctus*, and hence it seems not unlikely that the process of oviposition which occurs in *S. ovocinctus* will be found on further investigation to be of general occurrence in the genus *Strongyloides*.

FAMILY TRICHINELLIDÆ STILES and CRANE, 1910.

FAMILY DIAGNOSIS.—Nematoda: Esophagus consisting of a chain of single cells, the lumen of the esophagus passing through the center of each cell. Anterior portion of body, occupied by esophagus, usually very slender; posterior portion occupied by intestine and reproductive organs, more or less swollen. Spicule of male single or absent. One testicle. Only one ovary. Vulva situated at the junction of the anterior and posterior portions of the body.

TYPE GENUS.—*Trichinella* Railliet, 1895.

Two subfamilies may be recognized in this family.

KEY TO SUBFAMILIES OF TRICHINELLIDÆ.

- Male with spicule.....Trichurinae, p. 111
Male without spicule; only accidental in ruminants.....Trichinellinae, p. 120

Subfamily TRICHURINÆ Ransom, 1911.

SUBFAMILY DIAGNOSIS.—Trichinellidæ (p. 110): Male with spicule. Female deposits eggs characterized by the presence of an opening at each pole closed by a plug-like operculum. Development so far as known direct, without intermediate host, and without encysted larval stage. Eggs do not hatch until after they have been swallowed by a suitable host.

TYPE GENUS.—*Trichuris* Roederer and Wagler, 1761.

Two genera of this subfamily are represented among the nematodes of ruminants.

KEY TO GENERA OF TRICHURINÆ.

Anterior portion, or esophageal region, of body very slender, and considerably longer than the posterior portion which is much thicker and contains the reproductive organs; males 40 to 80 mm. long, females 48 to 70 mm. long *Trichuris*, p. 111

Posterior portion of body less than one-tenth of a millimeter in diameter; not much thicker than the anterior portion; anterior portion of body not as long as the posterior portion; males 8 to 13 mm. long, females 12 to 20 mm. long.

Capillaria, p. 117

Genus TRICHURIS Roederer and Wagler, 1761.

1761: *Trichuris* Roederer and Wagler in Roederer, 1761a, p. 243.

1782: *Trichocephalos* Goeze, 1782a, pp. 40, 112-123 (*Trichuris* renamed).

1788: *Trichocephalus* Schrank, 1788a, pp. 4-5.

1800: *Mastigodes* Zeder, 1800a, pp. 5-6 (*Trichuris* renamed).

1801: *Tricocephalus* Lamarck, 1801a, p. 338.

GENERIC DIAGNOSIS.—Trichurinæ (p. 111): Anterior portion or esophageal region of body, very long and slender; posterior portion of body containing the intestine and reproductive organs relatively thick and much shorter than the anterior portion. Posterior extremity of body blunt and rounded. Anus terminal or nearly terminal. On the ventral surface of the anterior portion of the body a broad longitudinal band (bacillary band) formed by a mass of punctiform projections, which are the points of small rod-like structures emanating from subcuticular cells and penetrating the cuticle. This bacillary band terminates near the beginning of the thick posterior portion of the body. Cuticle with annular striations whose posterior edges project slightly, giving a finely serrate appearance to the contour of the body. Annular striations of the cuticle absent from the ventral surface of the anterior portion of the body, stopping at the edges of the bacillary band.

Male. Posterior portion of body rolled dorsally into a spiral. Spicule surrounded by a prepuce-like sheath which evaginates when the spicule is protruded. External surface of the evaginated sheath smooth, or provided with little spines.

Female. Posterior portion of body may be slightly curved, but not rolled into a spiral. Vulva near the beginning of the thick posterior portion of the body. Shell of egg thick, usually brown in color, with an opening at each pole closed by a plug-like operculum. Eggs ellipsoidal.

TYPE SPECIES.—*Trichuris trichiura* (Linnaeus, 1767).

Six species of *Trichuris*, two of them very imperfectly known, occur in ruminants.

KEY TO SPECIES OF TRICHURIS.

(The very imperfectly known species *Trichuris cameli*, p. 116, and *T. giraffæ*, p. 117, are not included in this key.)

1. Spicule less than 2 mm. long *Trichuris discolor*, p. 114
- Spicule more than 2 mm. long 2

2. Sheath of spicule, when evaginated, without bulbous enlargement at end; armed with 20 longitudinal rows of conical spines; spicule 3 mm. long by 8μ thick.

Trichuris alcocki, p. 115

Sheath of spicule, when evaginated, with bulbous enlargement at end..... 3

3. Spines on bulbous enlargement of spicule sheath more than twice as long as the spines on the rest of the sheath; spicule 4.3 mm. long... *Trichuris globulosa*, p. 115

Spines on bulbous enlargement of spicule sheath not longer than the spines on the rest of the sheath; spicule 5 to 6 mm. or more in length

Trichuris ovis, p. 112

***Trichuris ovis* (Abildgaard, 1795)
Smith, 1908.**

(Figs. 138-140.)

1795: *Trichocephalus ovis* Abildgaard, 1795 (on the authority of Railliet, 1893a, p. 481).

1802: *Trichocephalus affinis* Rudolphi, 1802a, p. 7.

1803: *Mastigodes affinis* (Rudolphi) Zeder, 1803a, p. 70.

1908: *Trichuris ovis* (Abildgaard) Smith, 1908a, p. 269.

SPECIFIC DIAGNOSIS.—*Trichuris* (p. 111): The slender anterior portion of the body equals two-thirds to three-fourths the total length. Head less than 10μ in diameter, sometimes provided with two lateral vesicular swellings. The marginal rods of the bacillary band are larger than the others.

Male 50 to 80 mm. long; anterior portion of the body equal to about three-fourths the length. Spicule (*sp.*, fig. 139) of nearly equal thickness throughout, but slightly attenuated from in front posteriorly and terminating in a sharp point; length 5 to 6 mm. or more; diameter about 25μ . Sheath of spicule (*sh.*, fig. 139) very long, covered with little spines and with a bulbous enlargement at end when evaginated.

Female 50 to 70 mm. long; anterior portion of body equal to about two-thirds the total length. Eggs (fig. 140) dark brown in color, lemon-shaped, 70 to 80μ long, including the opercula, or 55 to 65μ excluding them, and 30 to 35μ broad.

HOSTS.—*Sheep (*Ovis aries*); *cattle (*Bos taurus*); *goat (*Capra hircus*); *moose (*Alce americanus*); Dorcas gazelle (*Gazella dorcas*); chamois (*Rupicapra rupicapra*); roe deer (*Capreolus capreolus*); giraffe (*Giraffa camelopardalis*); Bactrian camel (*Camelus bactrianus*); Arabian camel (*Camelus dromedarius*); *mule deer (*Odocoileus hemionus*); marsh deer (*Blastocerus paludosus*); red brocket (*Mazama rufa*); European elk (*Alce alces*); *spotted deer (*Cervus axis*); *fallow deer (*Dama dama*); stag (*Cervus elaphus*); llama (*Auchenia glama*); argali (*Ovis ammon*); *Mexican mountain sheep (*Ovis mexicana*); *Newfoundland caribou (*Rangifer terrænovæ*); prong-horned antelope (*Antilocapra americana*).

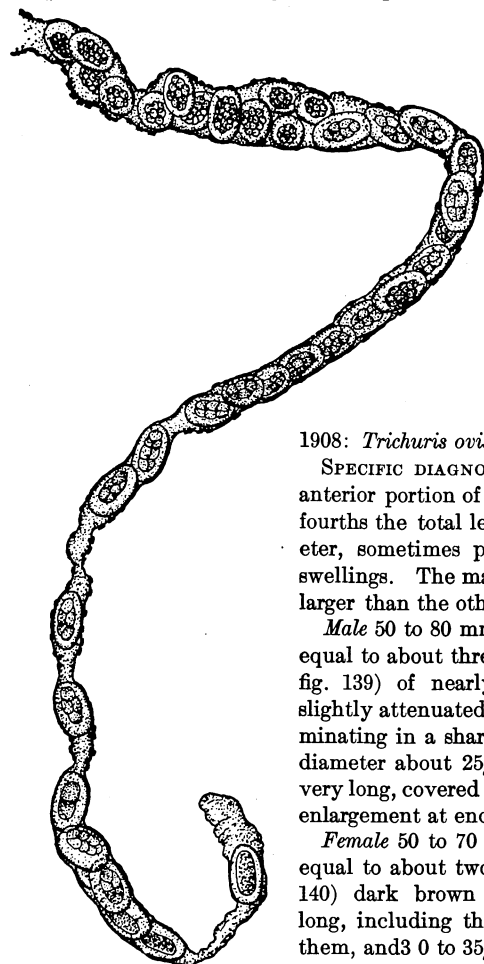


FIG. 137.—*Strongyloides ovocinctus*.
Egg-string. $\times 150$. (Original.)

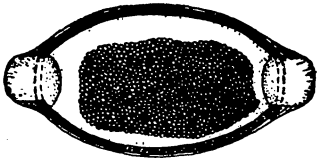


FIG. 140.—*Trichuris ovis*. Egg. $\times 600$.
(Original.)

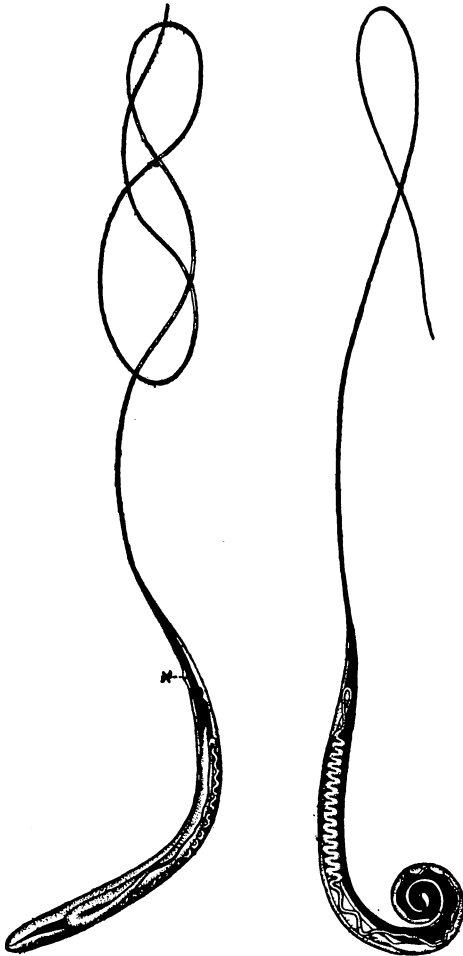


FIG. 138.—*Trichuris ovis*. Male at right, female at left.
*Vulva. $\times 5$. (After Curtice, 1890c, pl. 8, figs. 2, 3.)

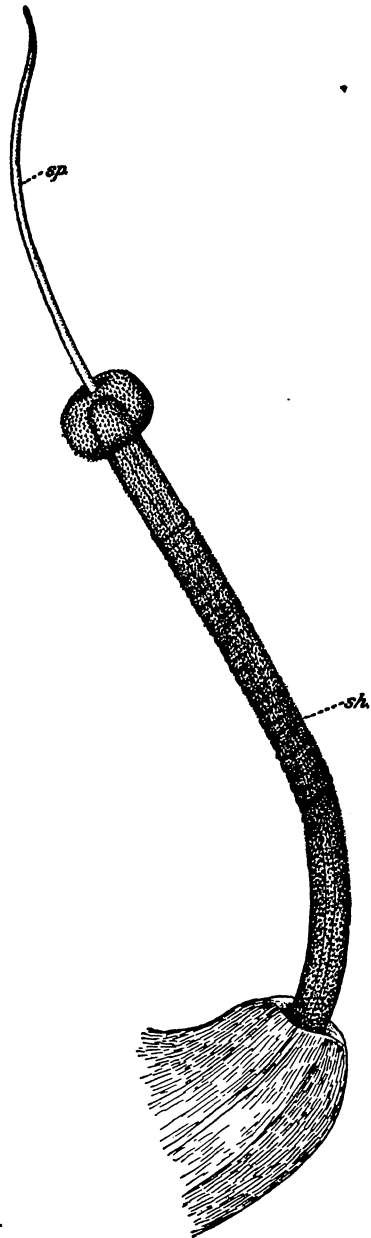


FIG. 139.—*Trichuris ovis*. Posterior end of body of male, with exerted spicule (*sp.*) and spicule sheath (*sh.*) Enlarged. (After Curtice, 1890c, pl. 28, fig. 4.)

LOCATION.—Large intestine, rarely in other parts of the alimentary tract.

LOCALITIES COLLECTED.—United States, Europe, Asia, Africa, South America, New Zealand, Australia.

This species is a common parasite, and has been frequently reported in various ruminants from all parts of the world. It is commonly met with in cattle, sheep, and goats in the United States. It apparently causes little if any trouble.

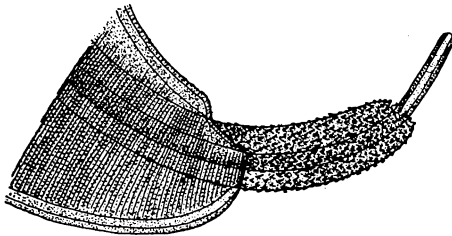


FIG. 141.—*Trichuris discolor*. Posterior end of body of male with exerted spicule and spicule sheath. Lateral view. Enlarged. (After Linstow, 1906, pl. 1, fig. 13).

Leuckart (1868a, pp. 497–502) demonstrated experimentally that this species develops directly from the egg stage without intermediate host and without free-living stages. Eggs of the parasite

kept in a moist medium in his laboratory from February to August contained fully formed embryos at the end of this time, which continued their development when fed to a lamb. How long the eggs may retain their vitality is uncertain, probably, however, several years.

Trichuris discolor (Linstow, 1906) Ransom, 1911.

(Figs. 141–142.)

1906: *Trichocephalus discolor* Linstow, 1906, *Spolia Zeylanica*, Colombo, pt. 11, v. 3, Jan., pp. 164, 173, pl. 1, figs. 13–14 (from *Bibos indicus* [= *Bos indicus*], Ceylon).

1911: *Trichuris discolor* (Linstow) Ransom, 1911, pp. 15, 111, 114, 121, figs. 141–142 (the present paper).

SPECIFIC DIAGNOSIS.—*Trichuris* (p. 111): Cuticle annulate at intervals of 9.1μ ; contour of the anterior portion of body serrate.

Male white, 45 mm. long by 0.14 mm. thick in front, 0.55 mm. behind; sheath of spicule spinose; spicule long and narrow, of even width except at the rounded apex, 1.76 mm. long by 11μ thick; hence not to be confounded with *T. ovis*.

Female 50 mm. long by 0.13 mm. thick in front, 0.67 mm. behind; anterior portion of body white, posterior portion yellow; eggs (fig. 142) 65 by 35μ with large spherical opercula at the poles.

Host.—Zebu (*Bos indicus*).

Location.—Stomach (?).

LOCALITY COLLECTED.—Ceylon.

The above description is taken from Linstow (1906, *Spolia Zeylanica*, Colombo, pt. 11, v. 3, Jan., p. 164).

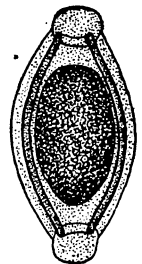


FIG. 142.—*Trichuris discolor*. Egg. Enlarged. (After Linstow, 1906, pl. 1, fig. 14.)

***Trichuris alcocki* (Linstow, 1906) Ransom, 1911.**

(Fig. 143.)

1906: *Trichocephalus alcocki* Linstow, 1906, Zool. Jahrb., Abt. f. Syst., v. 24 (1), pp. 7-8, pl. 1, fig. 9 (from intestine of *Cervus eldi*, India).

1911: *Trichuris alcocki* (Linstow) Ransom, 1911, pp. 15, 112, 115, 123, fig. 143 (the present paper).

SPECIFIC DIAGNOSIS.—*Trichuris* (p. 111): Annular striations of anterior portion of body at intervals of 6.5μ , interrupted by the bacillary band, whose breadth is equal to about seven-tenths of the diameter of the body. The annular striations give the anterior portion of the body a serrate contour.

Male 65 mm. long by 0.2 mm. in thickness anteriorly, 0.7 mm. posteriorly. Length of anterior portion of body three times the length of the posterior portion. Tail curved dorsalward in a semicircle. Spicule 3 mm. long, 8μ thick, attenuated at the end. Sheath of spicule, when evaginated a distance of 260μ , measures 26μ broad, is without posterior enlargement, and is armed with regularly arranged powerful spines. The spines are conical in shape and arranged in 20 longitudinal rows.

Female 62 mm. long by 0.2 mm. in thickness anteriorly, 0.86 mm. posteriorly. Anterior portion of body about $4\frac{1}{2}$ times as long as the posterior portion. Anus nearly terminal, slightly ventral. Eggs with thick shells, 52μ long by 31μ wide.

Host.—Thamin (*Cervus eldi*).

Location.—Intestine.

Locality collected.—India.

The foregoing diagnosis is taken from the original description given by Linstow (1906).

***Trichuris globulosa* (Linstow, 1901) Ransom, 1911.**

(Figs. 144-146.)

1901: *Trichocephalus globulosus* Linstow, 1901c, pp. 182-183, pl. 8, figs. 1-3 (from *Camelus dromedarius*).

1911: *Trichuris globulosa* (Linstow) Ransom, 1911, pp. 15, 112, 115-116, 123, figs. 144-146 (the present paper).

SPECIFIC DIAGNOSIS.—*Trichuris* (p. 111): The lateral bands are visible only in the anterior portion, or esophageal region of the body; their breadth is equal to about one-half the diameter of the body; they are composed of small circular structures closely pressed together; the usually rod-like structures are not recognizable; the cuticle is obliquely annulated at intervals of about 3μ .

Male about 40 mm. in length by 120μ in breadth anteriorly and 710μ posteriorly. The esophagus is about two-thirds the length of the body. The spicule is 4.3 mm. long, enlarged at the base; the posterior end tapers gradually to a fine point. The sheath of the spicule is spinose with a globular posteriorly truncated swelling at the end, and may be evaginated a distance of 750μ ; the spines are extraordinarily close set and point backwards (i. e., toward the body), measuring about 5μ long, except on

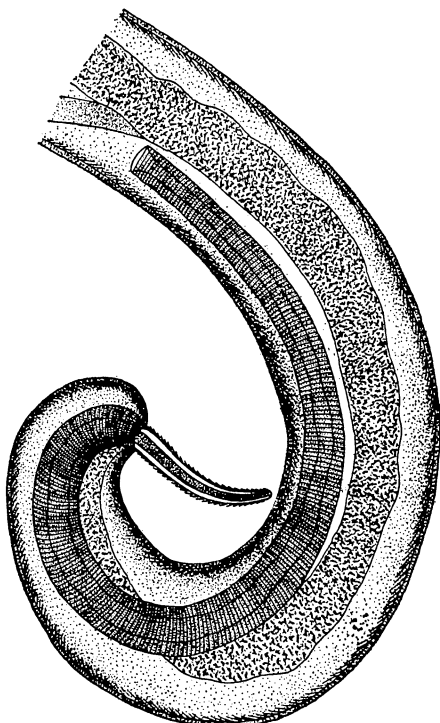


FIG. 143.—*Trichuris alcocki*. Posterior end of body of male. Lateral view. Enlarged. (After Linstow, 1906, pl. 1, fig. 9.)

the bulbous end where they are farther apart, directed radially, and measure 13μ in length. The seminal vesicle is about 8 mm. long.

Female attains a length of about 48 mm., with a breadth anteriorly of about 80μ , and a maximum breadth posteriorly of about 870μ . The esophagus is about three-fourths the length of the body. Vulva close behind the posterior end of the esophagus. Egg shell thin with a circular opening at each pole closed by a globular operculum. Length of egg including the opercula 68μ , without these, 60μ ; breadth, 36μ .

HOST.—Arabian camel (*Camelus dromedarius*).

LOCATION.—?

LOCALITY COLLECTED.—?Germany.

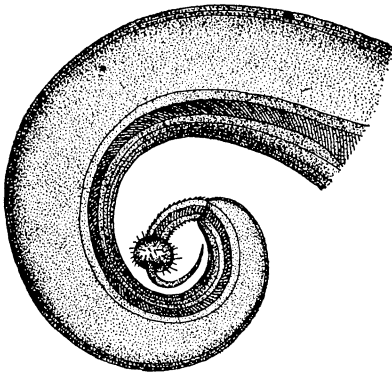


FIG. 144.—*Trichuris globulosa*. Posterior end of body of male. Lateral view. Enlarged. (After Linstow, 1901c, pl. 8, fig. 1.)

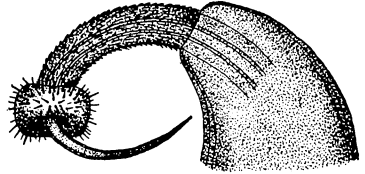


FIG. 145.—*Trichuris globulosa*. Posterior end of body of male. Lateral view. Enlarged. (After Linstow, 1901c, pl. 8, fig. 2.)



FIG. 146.—*Trichuris globulosa*. Egg. Enlarged. (After Linstow, 1901c, pl. 8, fig. 3.)

This species was described from specimens in the Senckenberg Museum at Frankfort-on-the-Main. The above diagnosis is based on Linstow's (1901c) original description.

***Trichuris cameli* (Rudolphi, 1819) Ransom, 1911.**

1819: *Trichocephalus cameli* Rudolphi, 1819a, pp. 18, 228 (from large intestine, *Camelus bactrianus* and *Camelus dromedarius*).

1849: *Trichocephalus echinophyllus* Nitzsch in Creplin, 1849a, p. 58 (from *Camelus dromedarius*. According to Railliet 1893a, p. 483, this species is probably identical with *Trichocephalus cameli* Rudolphi).

1911: *Trichuris cameli* (Rudolphi) Ransom, 1911, pp. 15, 111, 116–117, 123 (the present paper).

SPECIFIC DIAGNOSIS.—*Trichuris* (p. 111): Anterior portion of body equal to about three-fourths the total length. Spicule of male long, filiform, flat, terminating in a point. Sheath of spicule when evaginated covered with numerous spines and with a button-like enlargement at its extremity.

HOSTS.—Arabian camel (*Camelus dromedarius*); Bactrian camel (*Camelus bactrianus*).

LOCATION.—Large intestine.

LOCALITY COLLECTED.—Europe.

The Bureau of Animal Industry collection of parasites contains specimens of *Trichuris*, possibly belonging to this species, collected

from a dromedary which died at the National Zoological Park, Washington, D. C.

Trichuris giraffæ (Diesing, 1851) Ransom, 1911.

1851: *Trichocephalus giraffæ* Diesing, 1851a, p. 294 (from *Camelopardalis giraffa* [= *Giraffa camelo-pardalis*]).

1911: *Trichuris giraffæ* (Diesing) Ransom, 1911, pp. 15, 111, 117, 123 (the present paper.)

SPECIFIC DIAGNOSIS.—*Trichuris* (p. 111): Total length 75 to 100 mm. Anterior portion of body four-fifths the total length.

HOST.—Giraffe (*Giraffa camelopardalis*).

LOCATION.—Small intestine.

LOCALITY COLLECTED.—Egypt.

All that is known concerning this form is that Clot-Bey (1839, Bull. scient. acad. impériale d. sc. St. Petersburg (126), v. 6 (6), 19 août, pp. 94–95) found some whip worms of the size given, in the small intestine of a giraffe which died after having been kept at Cairo about one year.

Genus **CAPILLARIA** Zeder, 1800.

1800: *Capillaria* Zeder, 1800a, p. 5.

1819: *Trichosoma* Rudolphi, 1819a, pp. 13–16, 219–223 (*Capillaria* renamed).

1839: *Trichosomum* Creplin, 1839a, p. 278 (*Trichosoma* renamed).

1845: *Calodium* Dujardin, 1845a, pp. 4, 25–29 (?type species, *C. annulosum*).

GENERIC DIAGNOSIS.—*Trichurinæ* (p. 111): Body very slender, capillary. Bacillary bands present, dorsal, ventral, or lateral in position. Esophagus long and slender, gradually increasing in size posteriorly. Tail of male may be provided with membranous wings, and a membranous bursa-like structure, which are usually inconspicuous. Spicule long and slender surrounded by a sheath whose outer surface when the sheath is evaginated may be smooth or armed with spines. Vulva located near the base of the esophagus. Eggs ellipsoidal. Egg shell with an opening at each pole closed by a plug-like operculum.

TYPE SPECIES.—*Capillaria tumida* Zeder, 1803 = *Trichosoma brevicolle* Rudolphi, 1819.

Three species of *Capillaria* occur in ruminants.

KEY TO SPECIES OF CAPILLARIA.

Male 8 to 9 mm. long, female about 12 mm. long; spicule about 0.9 mm. long.

Capillaria brevipes, p. 117

Male 11 to 13 mm. long, female about 20 mm. long; spicule about 1.2 mm. long.

Capillaria longipes, p. 119

Male about 12 mm. long, female about 20 mm. long..... *Capillaria bovis*, p. 120

Capillaria brevipes Ransom, 1911.

(Figs. 147–149.)

1911: *Capillaria brevipes* Ransom, 1911, pp. 15, 117–119, 122, figs. 147–149 (the present paper).

SPECIFIC DIAGNOSIS.—*Capillaria* (p. 117): Body very slender, gradually increasing in size from the head backward, reaching its maximum thickness in the posterior region of the body some distance in front of the tail, toward which the thickness of the body again diminishes. Head less than 10μ in diameter.

Male 8 to 9 mm. long by 50μ in maximum thickness. Esophagus about 4 mm. in length. Spicule (*sp.*, fig. 148) about 0.9 mm. long. Sheath of spicule (*sh.*, fig. 148) considerably longer than the spicule, and when extruded about 10μ in diameter,

without spines. Tail curved. Along each side of the posterior end of the body, beginning 200 to 300 μ from the tip of the tail, there is a narrow membranous wing (*l. m.*, fig. 148) terminating opposite the anus, which is subterminal in position. The tail is supplied with a small membranous bursa-like structure (*b. m.*, fig. 148) supported on each side by a small leg-like process originating dorsally from the posterior end of the body. The shorter more slender distal portion of this process is bent forward almost at right angles to its proximal portion, which measures about 15 μ in length.

Female about 12 mm. long by 60 μ in maximum thickness. Esophagus about 5 mm. long. Diameter of body at base of esophagus about 50 μ . Posterior end of body

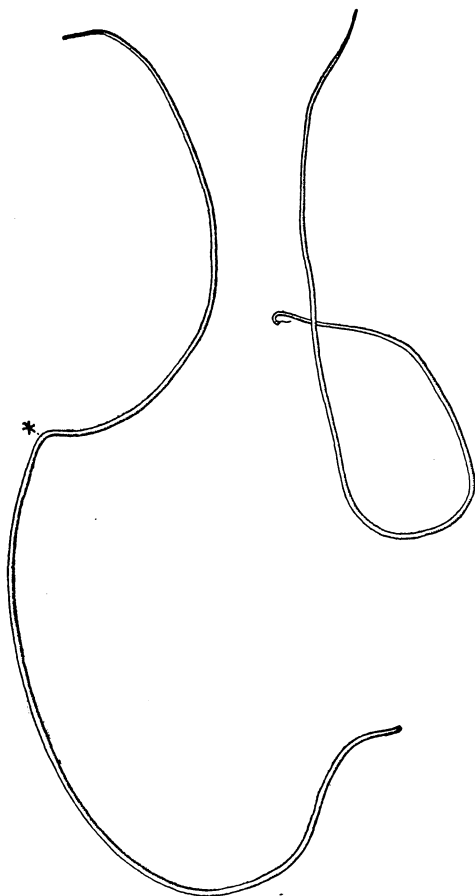


FIG. 147.—*Capillaria brevipes*. Male at right, female at left.
*Vulva. $\times 15$. (Original.)

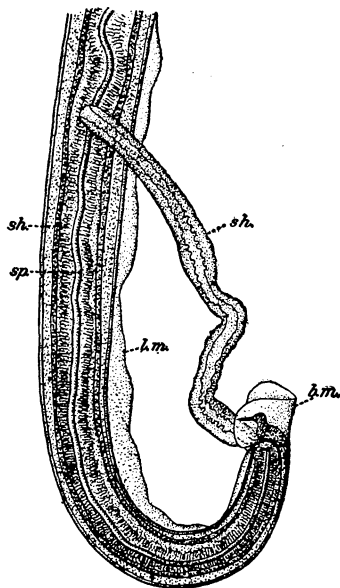


FIG. 148.—*Capillaria brevipes*. Posterior end of body of male. Lateral view. *b. m.*, bursal membrane; *l. m.*, lateral membrane; *sh.*, spicule sheath; *sp.*, spicule. $\times 300$. (Original.)

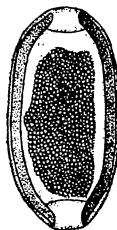


FIG. 149.—*Capillaria brevipes*. Egg. $\times 600$. (Original.)

blunt; anus terminal. Vulva situated just posterior of the base of the esophagus. Eggs (fig. 149) 50 μ long by 25 μ wide, including the opercula, shell 3 to 4 μ thick.

Host.—* Sheep (*Ovis aries*).

Location.—Small intestine.

Locality collected.—United States.

Type specimens.—Bureau of Animal Industry Helminthological Collection No. 4234, collected January 16, 1906, from the small intestine of a sheep at Bethesda, Md., by Dr. E. C. Stevenson.

This species has been frequently found in sheep at the Bureau of Animal Industry Experiment Station.

Capillaria longipes Ransom, 1911.

(Figs. 150-152.)

1911: *Capillaria longipes* Ransom, 1911, pp. 15, 117, 119-120, 122, figs. 150-152 (the present paper).

SPECIFIC DIAGNOSIS.—*Capillaria* (p. 117): Body very slender, gradually increasing in size from the head backward, reaching its maximum thickness in the posterior



FIG. 150.—*Capillaria longipes*. Male above, female below. *Vulva. $\times 15$. (Original.)

region of the body some distance in front of the tail, toward which the thickness of the body again diminishes. Head less than 10μ in diameter.

Male 11 to 13 mm. long by 50 to 60μ in maximum thickness. Esophagus 4 to 5 mm. in length. Diameter of body at base of esophagus about 40μ . Spicule (*sp.* fig. 151) about 1.2 mm. long. Sheath of spicule (*sh.*, fig. 151) considerably longer than spicule and about 12μ in diameter when extruded, without spines. Tail curved.

Along each side of the posterior end of the body beginning about 300μ from the tip of the tail, a rather broad membranous wing (*l. m.*, fig. 151) which extends as far as the anus, which is subterminal in position. Membranous bursa-like structure (*b. m.*, fig. 151) at the tip of the tail supported on each side by a leg-like process whose shorter, more slender distal portion is bent nearly at right angles to its proximal portion, which measures about 30μ in length.

Female about 20 mm. long by 80μ in maximum thickness. Esophagus 6 to 7 mm. long. Diameter of body at base of esophagus about 60μ . Posterior end of body blunt; anus terminal. Vulva situated just posterior of the base of the esophagus. Eggs (fig. 152) 45 to 50μ long, including the opercula, by 22 to 25μ wide; shell 1.5 to 2μ thick.

HOST.—* Prong-horned antelope (*Antilocapra americana*); * sheep (*Ovis aries*).

LOCATION.—Small intestine.

LOCALITY COLLECTED.—United States.

TYPE SPECIMENS.—Bureau of Animal Industry Helminthological Collection No. 4222, collected August 13, 1892, from the small intestine of a prong-horned antelope at Washington, D. C., by Dr. A. Hassall.

Capillaria bovis (Schnyder, 1906)
Ransom, 1911.

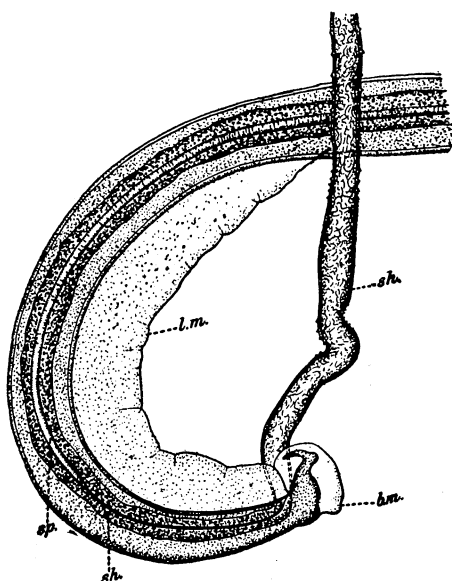


FIG. 151.—*Capillaria longipes*. Posterior end of body of male. Lateral view. *b. m.*, bursal membrane; *l. m.*, lateral membrane; *sh.*, spicule sheath; *sp.*, spicule. $\times 300$. (Original.)



FIG. 152.—*Capillaria longipes*.
Egg. $\times 600$. (Original.)

1906: *Trichosoma bovis* Schnyder, 1906a, p. 28 (from *Bos taurus*, Europe).

1911: *Capillaria bovis* (Schnyder) Ransom, 1911, pp. 15, 117, 120, 121 (the present paper).

SPECIFIC DIAGNOSIS.—*Capillaria*

(p. 117): *Male* about 12 mm. long by 75μ thick in the posterior region of the body.

Female about 20 mm. long by 95μ thick in the posterior region of the body. Eggs 47μ long by 27μ wide.

HOST.—Cattle (*Bos taurus*).

LOCATION.—Small intestine.

LOCALITY COLLECTED.—Switzerland.

Schnyder (1906a, pp. 28, 36) gives only a very brief description of this form, from which the above diagnosis is taken.

SUBFAMILY TRICHINELLINÆ Ransom, 1911.

SUBFAMILY DIAGNOSIS.—Trichinellidæ (p. 110): Male without spicule. Female ovoviviparous. Adults in intestine of host produce larvæ which penetrate into the muscles, become encysted, and develop to maturity when the flesh of this host is swallowed by another animal.

TYPE GENUS.—*Trichinella* Railliet, 1895.

KEY TO GENERA OF TRICHINELLINÆ.

One genus.....*Trichinella*, p. 121

Genus **TRICHINELLA** Railliet, 1895.

Trichinella spiralis (Owen, 1835) Railliet, 1895.

Trichinella spiralis is mentioned only as of passing interest in the present connection. The adults of this species may occur in the intestine of ruminants as the result of accidentally swallowing flesh infested with the encysted larvæ, but there is little likelihood of their ever being discovered unless they are specially looked for at the proper time after the ingestion of trichinous flesh, as, for example, in experimental infections.

COMPENDIUM OF SPECIES ARRANGED ACCORDING TO HOSTS.^a

Order GLIRES.

FAMILY LEPORIDÆ.

Lepus cuniculus. Rabbit.

* *Strongyloides papillosus*,^b p. 105.

Order UNGULATA.

Suborder ARTIODACTYLA.

FAMILY BOVIDÆ.

Addax nasomaculatus. Addax.

Bos taurus. Domestic ox.

Hæmonchus contortus, p. 50.

Bison bison. American Bison.

* *Hæmonchus contortus*, p. 50.

Bos grunniens. Yak.

Monodontus longecirratus, p. 34.

Bos indicus. Zebu.

Ascaris vitulorum, p. 25.

Agriostomum vryburgi, p. 27.

Monodontus phlebotomus, p. 31.

Nematodirus digitatus, p. 85.

Gongylonema scutatum, p. 100.

Gongylonema verrucosum, p. 102.

Trichuris discolor, p. 114.

Ascaris vitulorum, p. 25.

* *Monodontus phlebotomus*, p. 31.

* *Chabertia ovina*, p. 35.

? *Æsophagostomum columbianum*, p. 41.

* *Æsophagostomum radiatum*, p. 44.

* *Hæmonchus contortus*, p. 50.

* *Ostertagia ostertagi*, p. 56.

* *Cooperia punctata*, p. 74.

* *Cooperia oncophora*, p. 77.

* *Cooperia pectinata*, p. 81.

* *Nematodirus filicollis*, p. 82.

* *Trichostrongylus extenuatus*, p. 94.

* *Gongylonema scutatum*, p. 100.

* *Trichuris ovis*, p. 112.

Capillaria bovis, p. 120.

^a The author is indebted to Mr. E. A. Preble, Bureau of Biological Survey, United States Department of Agriculture, and to Mr. N. Hollister, United States National Museum, for their assistance in selecting the names of hosts used in this paper.

^b The asterisk (*) signifies that specimens of the species indicated have been collected in the United States from the host under which it is listed and that these specimens have been examined by the author.

Capra hircus. Domestic goat.

- * *Monodontus trigonocephalus*, p. 28.
- * *Chabertia ovina*, p. 35.
- * *Æsophagostomum columbianum*, p. 41.
- * *Æsophagostomum venulosum*, p. 46.
- * *Hæmonchus contortus*, p. 50.
- * *Ostertagia circumcincta*, p. 59.
- * *Ostertagia trifurcata*, p. 62.
- * *Cooperia curticei*, p. 71.
- * *Nematodirus filicollis*, p. 82.
- * *Trichostrongylus instabilis*, p. 88.
- * *Trichostrongylus vitrinus*, p. 92.
- * *Trichostrongylus extenuatus*, p. 94.
- * *Trichostrongylus capricola*, p. 96.
- * *Gongylonema scutatum*, p. 100.
- * *Strongyloides papillosus*, p. 105.
- * *Trichuris ovis*, p. 112.

Capra ibex. Alpine Ibex.

Eucyathostomum spinulosum, p. 40.

Gazella dorcas. Dorcas Gazelle.

- Chabertia ovina*, p. 35.
- Trichostrongylus instabilis*, p. 88.
- Trichostrongylus probolurus*, p. 90.
- Trichuris ovis*, p. 112.

Oryx leucoryx. White oryx.

Chabertia ovina, p. 35.

Ovis ammon. Argali.

- Chabertia ovina*, p. 35.
- Æsophagostomum venulosum*, p. 46.
- Hæmonchus contortus*, p. 50.
- Trichuris ovis*, p. 112.

Ovis aries. Domestic sheep.

- * *Ascaris ovis*, p. 25.
- * *Monodontus trigonocephalus*, p. 28.
- * *Chabertia ovina*, p. 35.
- * *Æsophagostomum columbianum*, p. 41.
- * *Æsophagostomum venulosum*, p. 46.

- * *Hæmonchus contortus*, p. 50.
- ? *Ostertagia ostertagi*, p. 56.
- * *Ostertagia circumcincta*, p. 59.
- * *Ostertagia trifurcata*, p. 62.
- * *Ostertagia marshalli*, p. 62.
- * *Ostertagia occidentalis*, p. 67.
- * *Cooperia curticei*, p. 71.
- * *Cooperia oncophora*, p. 77.
- * *Nematodirus filicollis*, p. 82.
- * *Trichostrongylus instabilis*, p. 88.
- Trichostrongylus colubriformis*, p. 90.
- Trichostrongylus probolurus*, p. 90.
- * *Trichostrongylus vitrinus*, p. 92.
- * *Trichostrongylus extenuatus*, p. 94.
- * *Trichostrongylus capricola*, p. 96.
- * *Gongylonema scutatum*, p. 100.
- Gongylonema verrucosum*, p. 102.
- * *Strongyloides papillosus*, p. 105.
- * *Trichuris ovis*, p. 112.
- * *Capillaria brevipes*, p. 117.
- * *Capillaria longipes*, p. 119.

Ovis canadensis. Mountain sheep.

- * *Cooperia oncophora*, p. 77.

Ovis mexicana. Mexican mountain sheep.

- * *Hæmonchus contortus*, p. 50.
- * *Trichostrongylus extenuatus*, p. 94.
- * *Trichuris ovis*, p. 112.

Ovis nahura. Bharal.

- * *Hæmonchus contortus*, p. 50.
- * *Ostertagia ostertagi*, p. 56.
- * *Trichostrongylus instabilis*, p. 88.
- * *Trichostrongylus extenuatus*, p. 94.

Rupicapra rupicapra. Chamois.

- Monodontus trigonocephalus*, p. 28.
- Chabertia ovina*, p. 35.
- Æsophagostomum venulosum*, p. 46.
- Hæmonchus contortus*, p. 50.
- Ostertagia brigantiaica*, p. 69.
- Trichuris ovis*, p. 112.

FAMILY ANTILOCAPRIDÆ.**Antilocapra americana. Prong-horned antelope.**

- * *Hæmonchus contortus*, p. 50.
- * *Ostertagia circumcincta*, p. 59.
- * *Nematodirus filicollis*, p. 82.
- * *Trichostrongylus instabilis*, p. 88.
- * *Trichostrongylus extenuatus*, p. 94.
- * *Trichostrongylus capricola*, p. 96.
- * *Strongyloides ovocinctus*, p. 108.
- Trichuris ovis*, p. 112.
- * *Capillaria longipes*, p. 119.

FAMILY GIRAFFIDÆ.

Giraffa camelopardalis. Giraffe.*Trichuris ovis*, p. 112.*Trichuris giraffæ*, p. 117.

FAMILY CERVIDÆ.

Alce alces. European elk.*Trichuris ovis*, p. 112.*Alce americanus*. Moose.* *Hæmonchus contortus*, p. 50.* *Trichuris ovis*, p. 112.*Blastocerus campestris*. Pampas deer.*Eucyathostomum longesubulatum*, p. 38.*Blastocerus paludosus*. Marsh deer.*Spiroptera verrucosa*, p. 104.*Trichuris ovis*, p. 112.*Capreolus capreolus*. Roe deer.*Chabertia ovina*, p. 35.*Æsophagostomum venulosum*, p. 46.* *Hæmonchus contortus*, p. 50.* *Nematodirus filicollis*, p. 82.* *Trichostrongylus instabilis*, p. 88.* *Trichostrongylus extenuatus*, p. 94.*Trichuris ovis*, p. 112.*Cervus axis*. Spotted deer.* *Trichuris ovis*, p. 112.*Cervus elaphus*. Stag.*Chabertia ovina*, p. 35.*Strongylus ventricosus*, p. 98.*Trichuris ovis*, p. 112.*Cervus eldi*. Thamin.*Trichuris alcocki*, p. 115.*Dama dama*. Fallow deer.*Chabertia ovina*, p. 35.* *Æsophagostomum venulosum*, p. 46.*Nematodirus filicollis*, p. 82.* *Trichuris ovis*, p. 112.*Mazama nana*. Pygmy brocket.(? *Hæmonchus*) *bispinosus*, p. 54.*Spiroptera verrucosa*, p. 104.*Mazama rufa*. Red brocket.*Eucyathostomum longesubulatum*, p. 38.*Trichuris ovis*, p. 112.*Mazama* sp.* *Hæmonchus contortus*, p. 50.*Odocoileus hemionus*. Mule deer.* *Hæmonchus contortus*, p. 50.* *Trichostrongylus extenuatus*, p. 94.* *Trichuris ovis*, p. 112.*Rangifer terræ-novæ*. Newfoundland caribou.* *Hæmonchus contortus*, p. 50.* *Ostertagia circumcincta*, p. 59.* *Trichostrongylus extenuatus*, p. 94.* *Trichuris ovis*, p. 112.

FAMILY CAMELIDÆ.

Auchenia glama. Llama.*Trichuris ovis*, p. 112.*Camelus bactrianus*. Bactrian camel.* *Trichostrongylus instabilis*, p. 88.* *Trichostrongylus probolurus*, p. 90.*Trichuris ovis*, p. 112.*Trichuris cameli*, p. 116.*Camelus dromedarius*. Arabian camel.*Æsophagostomum venulosum*, p. 46.*Hæmonchus longistipes*, p. 54.* *Ostertagia mentulata*, p. 68.*Nematodirus spathiger*, p. 85.* *Trichostrongylus instabilis*, p. 88.*Trichostrongylus probolurus*, p. 90.*Trichostrongylus vitrinus*, p. 92.*Trichuris ovis*, p. 112.*Trichuris globulosa*, p. 115.*Trichuris cameli*, p. 116.

Order PRIMATES.

FAMILY CERCOPITHECIDÆ.

Papio hamadryas. Arabian baboon.*Trichostrongylus instabilis*, p. 88.

FAMILY HOMINIDÆ.

Homo sapiens. Man.*Hæmonchus contortus*, p. 50.*Trichostrongylus instabilis*, p. 88.*Trichostrongylus probolurus*, p. 90.*Trichostrongylus vitrinus*, p. 92.

ADDENDUM.

An important article by Railliet and Henry (1910, Quelques helminthes nouveaux ou peu connus du groupe des Bunostomiens, in Bulletin de la Société de Pathologie exotique, Paris, v. 3 (5), 11 mai, pp. 311–315) has come to hand too late for consideration in the preparation of the present paper.

In conformity with the opinion of these authors I consider that the forms which I have grouped in the subfamily Metastrongylinæ should go into the subfamily Trichostrongylinæ Leiper, 1908 (type genus *Trichostrongylus*). Wherever I have used the name Metastrongylinæ the name Trichostrongylinæ should therefore be substituted. The subfamily Metastrongylinæ is accordingly restricted to include only the genus *Metastrongylus* and certain other genera whose species are parasitic in the respiratory tract and circulatory system.

Monodontus semicircularis and *Bunostomum trigonocephalum* are apparently not congeneric. The genus *Bunostomum* may therefore be recognized, with the three species *Bunostomum trigonocephalum*, *B. phlebotomum*, and *B. longecirratum*. These names may be substituted for *Monodontus trigonocephalus*, *M. phlebotomus*, and *M. longecirratus* which have been used in the present paper for the species in question.

In the Strongylinæ should be included the genus *Gaigeria* Railliet and Henry, 1910, closely related to *Bunostomum*. Its type and only known species, *Gaigeria pachyscelis* Railliet and Henry, 1910, has been found in the intestine of sheep in India and Africa and doubtfully in cattle in India.

INDEX.

(Synonyms are printed in *italics*; principal page references in bold-faced type.)

	Page.
<i>Acuaria</i>	103, 104
<i>acutum</i> , <i>Esophagostomum</i>	46
<i>Addax nasomaculatus</i>	52, 121
<i>affinis</i> , <i>Mastigodes</i>	112
<i>Trichocephalus</i>	112
<i>Agriostomum</i>	14, 26, 27
<i>vryburgi</i>	14, 18, 27 , 121
<i>Alce alces</i>	112, 123
<i>americanus</i>	52, 112, 123
<i>alcocki</i> , <i>Trichocephalus</i>	115
<i>Trichuris</i>	15, 112, 115 , 123
<i>americana</i> , <i>Antilocapra</i>	52, 62, 84, 88, 94, 98, 108, 112, 120, 122
<i>americanus</i> , <i>Alce</i>	52, 112, 123
<i>ammon</i> , <i>Ovis</i>	37, 47, 53, 112, 122
<i>ammonis</i> , <i>Strongylus</i>	46
<i>Angiostoma</i>	104
<i>Angiostomidae</i>	15, 23, 24, 104
<i>annulosum</i> , <i>Calodium</i>	117
<i>Anthuris</i>	103
<i>anthuris</i> , <i>Spiroptera</i>	103
<i>Antilocapra americana</i>	52, 62, 84, 88, 94, 98, 108, 112, 120, 122
<i>Antilocapridae</i>	122
<i>Antilope rupicapra</i>	35
<i>aries</i> , <i>Ovis</i>	25, 30, 31, 37, 43, 47, 52, 58, 62, 66, 67, 73, 79, 82, 84, 88, 90, 92, 94, 96, 98, 101, 102, 105, 112, 118, 120, 122
<i>Artiodactyla</i>	121
<i>Ascaridae</i>	13, 18, 19, 20, 23, 24
<i>Ascaris</i>	13, 17, 23, 24-25
<i>equorum</i>	25
<i>filicollis</i>	82
<i>lumbricoides</i>	24, 25
<i>megalocephala</i>	25
<i>ovis</i>	13, 25 , 122
<i>suum</i>	25
<i>vituli</i>	25
<i>vitulorum</i>	13, 17, 25 , 121
<i>Auchenia glama</i>	112, 123
<i>axis</i> , <i>Cervus</i>	112, 123
<i>bactrianus</i> , <i>Camelus</i>	88, 92, 112, 116, 123
<i>Bibos indicus</i>	27, 85, 114
<i>Bison bison</i>	52, 121
<i>bispinosus</i> , (? <i>Hæmonchus</i>).....	14, 47, 50, 54 , 123
<i>Strongylus</i>	54
<i>Blastocerus campestris</i>	38, 123
<i>paludosus</i>	104, 112, 123
<i>Bos grunniens</i>	35, 121
<i>indicus</i>	14, 15, 25, 27, 34, 85, 86, 101, 102, 114, 121
<i>taurus</i>	25, 34, 37, 43, 44, 46, 52, 58, 77, 79, 81, 84, 94, 99, 101, 112, 120, 121
<i>Bovidæ</i>	121
<i>bovis</i> , <i>Capillaria</i>	15, 117, 120 , 121
<i>Esophagostomum</i>	44
<i>Strongyloides</i>	74, 77
<i>Trichosoma</i>	120

	Page.
<i>brevicollis</i> , <i>Trichosoma</i>	117
<i>brevipes</i> , <i>Capillaria</i>	15, 117-119 , 122
<i>brigantiaca</i> , <i>Ostertagia</i>	14, 55, 69 , 122
<i>Bunostomum</i>	27, 28
<i>longecirratum</i>	34
<i>phlebotomum</i>	31
<i>radiatum</i>	31
<i>trigonocephalum</i>	27, 30
<i>Calodium</i>	117
<i>annulosum</i>	117
<i>cameli</i> , <i>Trichocephalus</i>	116
<i>Trichuris</i>	15, 111, 116-117 , 123
<i>Camelidæ</i>	123
<i>Camelopardalis giraffa</i>	117
<i>camelopardalis</i> , <i>Giraffa</i>	112, 117, 123
<i>Camelus bactrianus</i>	88, 92, 112, 116, 123
<i>dromedarius</i>	47, 54, 69, 85, 88, 92, 94, 112, 116, 123
<i>campestris</i> , <i>Blastocerus</i>	38, 123
<i>Cervus</i>	38
<i>canadensis</i> , <i>Ovis</i>	79, 122
<i>Capillaria</i>	15, 17, 20, 111, 117 , 119, 120
<i>bovis</i>	15, 117, 120 , 121
<i>brevipes</i>	15, 117-119 , 122
<i>longipes</i>	15, 117, 119-120 , 122
<i>tumida</i>	117
<i>Capra hircus</i>	31, 37, 43, 46, 47, 52, 62, 73, 84, 88, 94, 96, 98, 101, 105, 112, 122
<i>ibex</i>	40, 122
<i>Capreolus capreolus</i>	37, 47, 52, 84, 88, 94, 112, 123
<i>capricola</i> , <i>Trichostrongylus</i>	14, 87, 96-98 , 122
<i>Cercopithecidæ</i>	124
<i>cernua</i> , <i>Uncinaria</i>	30
(<i>Monodontus</i>)	30
<i>cernuus</i> , <i>Dochmius</i>	30
<i>Strongylus</i>	30
(<i>Monodontus</i>)	30
<i>cervicornis</i> , <i>Strongylus</i>	56, 59
<i>Cervidæ</i>	123
<i>Cervus axis</i>	112, 123
<i>campestris</i>	38
<i>dichotomus</i>	104
<i>elaphus</i>	37, 74, 98, 112, 123
<i>eldi</i>	115, 123
<i>nambi</i>	54, 104
<i>rufus</i>	38
<i>Chabertia</i>	14, 17, 18, 26, 35 , 37
<i>ovina</i>	14, 15, 35-38 , 121, 122, 123
<i>circumcincta</i> , <i>Ostertagia</i>	14, 55, 58, 59-62 , 122, 123
<i>circumcinctus</i> , <i>Strongylus</i>	59, 62
<i>colubriformis</i> , <i>Strongylus</i>	88, 90
<i>Trichostrongylus</i>	14, 87, 90 , 122
<i>columbianum</i> , <i>Æsophagostoma</i>	41
<i>Æsophagostomum</i>	14, 41-44 , 46, 47, 121, 122
<i>contortus</i> , <i>Hæmonchus</i>	14, 15, 34, 49, 50-54 , 82, 85, 99, 121, 122, 123, 124
<i>Strongylus</i>	35, 46, 50
<i>convolutus</i> , <i>Strongylus</i>	56
<i>Cooperia</i>	14, 17, 49, 69-71 , 77, 79, 81
<i>curticei</i>	14, 70, 71-74 , 77, 122
<i>curticii</i>	71
<i>oncophora</i>	14, 71, 74, 76, 77-79 , 99, 121, 122
<i>pectinata</i>	14, 71, 80, 81-82 , 121
<i>punctata</i>	14, 70, 74-77 , 82, 121
<i>crenatum</i> , <i>Gongylonema</i>	102
<i>cuniculus</i> , <i>Lepus</i>	105, 121
<i>curticei</i> , <i>Cooperia</i>	14, 70, 71-74 , 77, 122
<i>Strongylus</i>	71, 74, 79
<i>curticii</i> , <i>Cooperia</i>	71
<i>Strongylus</i>	71, 74
<i>Dama dama</i>	37, 47, 84, 112, 123

	Page.
dentatum, <i>Æsophagostomum</i>	41
<i>dichotomus</i> , <i>Cervus</i>	104
digitatus, <i>Nematodirus</i>	14, 82, 85-86 , 121
<i>Strongylus</i>	85
<i>dilatatum</i> , <i>Æsophagostomum</i>	44
<i>dilatatus</i> , <i>Strongylus</i>	44
discolor, <i>Trichocephalus</i>	114
<i>Trichuris</i>	15, 111, 114 , 121
<i>Dispharagus</i>	103
<i>Dochmius cernuus</i>	30
<i>hypostomus</i>	30, 35
<i>radiatus</i>	31
<i>domestica</i> , <i>Ovis</i>	25
dorcas, <i>Gazella</i>	37, 88, 92, 112, 122
dromedarius, <i>Camelus</i>	47, 54, 69, 85, 88, 92, 94, 112, 116, 123
<i>echinophyllus</i> , <i>Trichocephalus</i>	116
elaphus, <i>Cervus</i>	37, 74, 98, 112, 123
eldi, <i>Cervus</i>	115, 123
equorum, <i>Ascaris</i>	25
<i>Eucyathostomum</i>	14, 18, 26, 38 , 40
<i>longesubulatum</i>	14, 38-40 , 123
<i>spinulosum</i>	14, 38, 40 , 122
extenuatus, <i>Strongylus</i>	94
<i>Trichostrongylus</i>	14, 17, 82, 87, 94-96 , 108, 121, 122, 123
<i>Filaria</i>	99
<i>scutata</i>	100
<i>verrucosa</i>	104
Filariidæ.....	14, 19, 20, 23, 24, 99-100 , 103
filicollis, <i>Ascaris</i>	82
<i>Fusaria</i>	82
<i>Nematodirus</i>	14, 82-85 , 86, 107, 121, 122, 123
<i>Strongylus</i>	50, 82, 107
fordii, <i>Strongylus</i>	14, 47, 99
<i>Fusaria</i>	24
<i>filicollis</i>	82
<i>Gazella dorcas</i>	37, 88, 92, 112, 122
<i>Giraffa camelopardalis</i>	112, 117, 123
<i>giraffa</i> , <i>Camelopardalis</i>	117
<i>giraffæ</i> , <i>Trichocephalus</i>	117
<i>Trichuris</i>	15, 111, 117 , 123
Giraffidæ.....	123
glama, <i>Auchenia</i>	112, 123
Glires.....	121
globulosa, <i>Trichuris</i>	15, 112, 115-116 , 123
<i>globulosus</i> , <i>Trichocephalus</i>	115
<i>Gongylonema</i>	14, 17, 23, 100 , 102
<i>crenatum</i>	102
<i>minimum</i>	100
<i>scutatum</i>	14, 100-101 , 121, 122
<i>verrucosum</i>	14, 17, 100, 102 , 121, 122
<i>gracilis</i> , <i>Strongylus</i>	94
grunniens, <i>Bos</i>	35, 121
<i>Hæmonchus</i>	14, 18, 21, 22, 47, 49-50 , 54
<i>contortus</i>	14, 15, 34, 49, 50-54 , 82, 85, 99, 121, 122, 123, 124
<i>longistipes</i>	14, 54 , 123
<i>sp.</i>	62
(? <i>Hæmonchus</i>) <i>bispinosus</i>	14, 47, 50, 54 , 123
hamadryas, <i>Papio</i>	88, 124
<i>harkert</i> , <i>Strongylus</i>	56
hemionus, <i>Odocoileus</i>	52, 94, 112, 123
hircus, <i>Capra</i>	31, 37, 43, 46, 47, 52, 62, 73, 84, 88, 94, 96, 98, 101, 105, 112, 122
Hominidæ.....	124
<i>Homo sapiens</i>	53, 88, 92, 94, 124
<i>hypostomum</i> , <i>Sclerostoma</i>	30, 35
<i>Sclerostomum</i>	35
<i>hypostomus</i> , <i>Dochmius</i>	30, 35
<i>Strongylus</i>	35

	Page.
ibex, <i>Capra</i>	40, 122
indicus, <i>Bibos</i>	27, 85, 114
<i>Bos</i>	14, 15, 25, 27, 34, 85, 86, 101, 102, 114, 121
<i>inflatum</i> , <i>Esophagostoma</i>	44
<i>Esophagostomum</i>	44
var. <i>ovis</i> , <i>Esophagostoma</i>	46
<i>inflatus</i> , <i>Strongylus</i>	44
instabilis, <i>Strongylus</i>	59, 88
<i>Trichostrongylus</i>	14, 87, 88-89 , 90, 92, 96, 122, 123, 124
<i>intestinalis</i> , <i>Strongyloides</i>	105
jubata, <i>Myrmecophaga</i>	44
Leporidae.....	121
<i>Lepus cuniculus</i>	105, 121
leucoryx, <i>Oryx</i>	37, 122
<i>Lombricoides</i>	24
<i>longecirratum</i> , <i>Bunostomum</i>	34
longecirratus, <i>Monodontus</i>	14, 28, 34-35 , 121
<i>Strongylus</i>	34
longesubulatum, <i>Eucyathostomum</i>	14, 38-40 , 123
<i>Sclerostomum</i>	38
longipes, <i>Capillaria</i>	15, 117, 119-120 , 122
longistipes, <i>Hæmonchus</i>	14, 54 , 123
longus, <i>Rhabdonema</i>	105
<i>Strongyloides</i>	105, 107, 108
lumbricoides, <i>Ascaris</i>	24, 25
marshalli, <i>Ostertagia</i>	14, 55, 62-67 , 68, 122
<i>Mastigodes</i>	111
<i>affinis</i>	112
Mazama nana.....	54, 104, 123
rufa.....	38, 112, 123
sp.....	52, 123
<i>megalocephala</i> , <i>Ascaris</i>	25
mentulata, <i>Ostertagia</i>	14, 55, 68-69 , 70, 123
Metastrongylinae.....	14, 26, 47-49 , 54, 69, 82, 86, 98, 99
Metastrongylus.....	47
mexicana, <i>Ovis</i>	53, 94, 112, 122
minimum, <i>Gongylonema</i>	100
Monodon.....	28
Monodonta.....	28
Monodontes.....	28
Monodontus.....	14, 26, 27-28 , 30, 33, 34
longecirratus.....	14, 28, 34-35 , 121
phlebotomus.....	14, 21, 28, 31-34 , 121
semicircularis.....	28
sp.....	31
trigonocephalus.....	14, 21, 28-31 , 122
<i>wedlii</i>	30
(<i>Monodontus</i>) cernua, <i>Uncinaria</i>	30
cernuus, <i>Strongylus</i>	30
<i>Myrmecophaga jubata</i>	44
<i>Myzomimus</i>	100
<i>scutatus</i>	100
nahura, <i>Ovis</i>	53, 58, 88, 94, 122
nambi, <i>Cervus</i>	57, 104
nana, <i>Mazama</i>	54, 104, 123
nasomaculatus, <i>Addax</i>	52, 121
Nematoda.....	13, 24, 26, 99, 104, 110
Nematodirus.....	14, 20, 21, 23, 49, 82 , 85, 86
digitatus.....	14, 82, 85-86 , 121
filicollis.....	14, 82-85 , 86, 107, 121, 122, 123
spathiger.....	14, 82, 85 , 123
occidentalis, <i>Ostertagia</i>	14, 55, 67-68 , 69, 122
Odocoileus hemionus.....	52, 94, 112, 123
<i>Esophagostoma columbianum</i>	41
<i>inflatum</i>	41
var. <i>ovis</i>	46
<i>venulosum</i>	46

	Page.
<i>Cesophagostomum</i>	14, 17, 18, 26, 40-41 , 44, 46
<i>acutum</i>	46
<i>bovis</i>	44
<i>columbianum</i>	14, 41-44 , 46, 47, 121, 122
<i>dentatum</i>	41
<i>dilatatum</i>	44
<i>inflatum</i>	44
<i>radiatum</i>	14, 41, 44-46 , 121
<i>subulatum</i>	41
<i>venulosum</i>	14, 41, 46-47 , 49, 122, 123
<i>oncophora</i> , Cooperia.....	14, 71, 74, 76, 77-79 , 99, 121, 122
<i>oncophorus</i> , <i>Strongylus</i>	77
<i>Oryx leucoryx</i>	37, 122
<i>ostertagi</i> , <i>Ostertagia</i>	14, 55, 56-59 , 82, 121, 122
<i>Strongylus</i>	56
<i>Ostertagia</i>	14, 21, 49, 54-55 , 56, 58, 59, 62, 67, 68, 69
<i>brigantiaca</i>	14, 55, 69 , 122
<i>circumcincta</i>	14, 55, 58, 59-62 , 122, 123
<i>marshalli</i>	14, 55, 62-67 , 68, 122
<i>mentulata</i>	14, 55, 68-69 , 70, 123
<i>occidentalis</i>	14, 55, 67-68 , 69, 122
<i>ostertagi</i>	14, 55, 56-59 , 82, 121, 122
<i>trifurcata</i>	14, 55, 62 , 63, 122
<i>ovina</i> , <i>Chabertia</i>	14, 15, 35-38 , 121, 122, 123
<i>ovinum</i> , <i>Sclerostomum</i>	35
<i>ovinus</i> , <i>Strongylus</i>	35
<i>Ovis ammon</i>	37, 47, 53, 112, 122
<i>aries</i>	25,
30, 31, 37, 43, 47, 52, 58, 62, 66, 67, 73, 79, 82, 84, 88,	
90, 92, 94, 96, 98, 101, 102, 105, 112, 118, 120, 122	
79, 122	
<i>canadensis</i>	25
<i>domestica</i>	25
<i>mexicana</i>	53, 94, 112, 122
<i>nahura</i>	53, 58, 88, 94, 122
<i>ovis</i> , <i>Ascaris</i>	13, 25 , 122
<i>Trichocephalus</i>	112
<i>Trichuris</i>	15, 112-114 , 121, 122, 123
<i>ovocinctus</i> , <i>Strongyloides</i>	15, 18, 23, 105, 108-110 , 112, 122
<i>paludosus</i> , <i>Blastocerus</i>	104, 112, 123
<i>papillosum</i> , <i>Trichosoma</i>	105, 107
<i>papillosus</i> , <i>Strongyloides</i>	15, 105-108 , 109, 110, 121, 122
<i>Papio hamadryas</i>	88, 124
<i>pectinata</i> , Cooperia.....	14, 71, 80, 81-82 , 121
<i>phlebotomum</i> , <i>Bunostomum</i>	31
<i>phlebotomus</i> , <i>Monodontus</i>	14, 21, 28, 31-34 , 121
<i>placei</i> , <i>Strongylus</i>	50
<i>Primates</i>	124
<i>probolurus</i> , <i>Strongylus</i>	90
<i>Trichostrongylus</i>	14, 87, 90-92 , 122, 123, 124
<i>Pseudorhabditis</i>	104
<i>punctata</i> , Cooperia.....	14, 70, 74-77 , 82, 121
<i>punctatus</i> , <i>Strongylus</i>	74
<i>radiata</i> , <i>Uncinaria</i>	31
<i>radiatum</i> , <i>Bunostomum</i>	31
<i>Cesophagostomum</i>	14, 41, 44-46 , 121
<i>radiatus</i> , <i>Dochmius</i>	31
<i>Strongylus</i>	31, 44, 46, 47
<i>Rangifer terrænovæ</i>	53, 62, 94, 112, 123
<i>retortæformis</i> , <i>Strongylus</i>	88, 94
<i>Trichostrongylus</i>	86
<i>Rhabdonema longus</i>	105
<i>rufa</i> , Mazama.....	38, 112, 123
<i>rufus</i> , <i>Cervus</i>	38
<i>rupicapra</i> , <i>Antilope</i>	35
<i>Rupicapra rupicapra</i>	31, 35, 37, 47, 52, 69, 112, 122
<i>sapiens</i> , Homo.....	53, 88, 92, 94, 124

	Page.
<i>Sclerostoma hypostomum</i>	30, 35
<i>Sclerostomum hypostomum</i>	35
<i>longesubulatum</i>	38
<i>ovinum</i>	35
<i>spinulosum</i>	40
<i>scutata</i> , <i>Filaria</i>	100
<i>Spiroptera</i>	100
<i>scutatum</i> , <i>Gongylonema</i>	14, 100-101, 121, 122
<i>scutatus</i> , <i>Myzomimus</i>	100
<i>semicircularis</i> , <i>Monodontus</i>	28
<i>spathiger</i> , <i>Nematodirus</i>	14, 82, 85, 123
<i>Strongylus</i>	85
<i>spinulosum</i> , <i>Eucyathostomum</i>	14, 38, 40, 122
<i>Sclerostomum</i>	40
<i>spinulosus</i> , <i>Strongylus</i> (?= <i>Eucyathostomum</i>).....	40
<i>spiralis</i> , <i>Trichinella</i>	15, 20, 121
<i>Spiroptera</i>	14, 100, 103-104
<i>anthuris</i>	103
<i>scutata</i>	100
<i>verrucosa</i>	14, 102, 103, 104, 123
<i>verrucosa</i>	102
<i>stercoralis</i> , <i>Strongyloides</i>	105, 107, 110
<i>Stomachida</i>	24
<i>Strongiloides</i>	104
<i>Strongylidæ</i>	14, 18, 19, 20, 21, 22, 23, 24, 26, 47
<i>Strongylinæ</i>	14, 26, 27, 35, 38, 40
<i>Strongyloides</i>	15, 17, 18, 19, 23, 104-105, 108, 109, 110
<i>bovis</i>	74, 77
<i>intestinalis</i>	105
<i>longus</i>	105, 107, 108
<i>ovocinctus</i>	15, 18, 23, 105, 108-110, 112, 122
<i>papillosus</i>	15, 105-108, 109, 110, 121, 122
<i>stercoralis</i>	105, 107, 110
<i>suis</i>	108
<i>Strongylus</i>	26, 99
<i>ammonis</i>	46
<i>bispinosus</i>	54
<i>cernuus</i>	30
<i>cervicornis</i>	56, 59
<i>circumcinctus</i>	59, 62
<i>colubriformis</i>	88, 90
<i>contortus</i>	35, 46, 50
<i>convolutus</i>	56
<i>curticei</i>	71, 74, 79
<i>curticii</i>	71, 74
<i>digitatus</i>	85
<i>dilatatus</i>	44
(?= <i>Eucyathostomum</i>) <i>spinulosus</i>	40
<i>extenuatus</i>	94
<i>filicollis</i>	50, 82, 107
<i>fordii</i>	14, 47, 99
<i>gracilis</i>	94
<i>harkeri</i>	56
<i>hypostomus</i>	35
<i>inflatus</i>	44
<i>instabilis</i>	59, 88
<i>longecirratus</i>	34
(<i>Monodontus</i>) <i>cernuus</i>	30
<i>oncophorus</i>	77
<i>ostertagi</i>	56
<i>ovinus</i>	35
<i>placei</i>	50
<i>probolurus</i>	90
<i>punctatus</i>	74
<i>radiatus</i>	31, 44, 46, 77
<i>retortæformis</i>	88, 94
<i>sp</i>	56, 74

	Page.
<i>Strongylus spathiger</i>	85
<i>subtilis</i>	88
<i>trigonocephalus</i>	28
<i>ventricosus</i>	14, 47, 98-99 , 123
<i>ventricosus</i>	71, 73, 77, 99
<i>venulosus</i>	46
<i>vicarius</i>	59, 62
<i>subtilis</i> , <i>Strongylus</i>	88
<i>Trichostrongylus</i>	88
<i>subulatum</i> , <i>Cesophagostomum</i>	41
<i>suis</i> , <i>Strongyloides</i>	108
<i>suum</i> , <i>Ascaris</i>	25
<i>taurus</i> , <i>Bos</i>	25, 34, 37, 43, 44, 46, 52, 58, 77, 79, 81, 84, 94, 99, 101, 112, 120, 121
<i>terrænovæ</i> , <i>Rangifer</i>	53, 62, 94, 112, 123
<i>Trichinella</i>	15, 110, 120, 121
<i>spiralis</i>	15, 20, 121
<i>Trichinellidæ</i>	15, 18, 19, 20, 22, 23, 24, 110 , 120
<i>Trichinellinæ</i>	15, 110, 120-121
<i>trichiura</i> , <i>Trichuris</i>	111
<i>Trichocephalos</i>	111
<i>Trichocephalus</i>	111
<i>affinis</i>	112
<i>alcocki</i>	115
<i>cameli</i>	116
<i>discolor</i>	114
<i>echinophyllus</i>	116
<i>giraffæ</i>	117
<i>globulosus</i>	115
<i>ovis</i>	112
<i>Trichosoma</i>	117
<i>bovis</i>	120
<i>brevicollis</i>	117
<i>papillosum</i>	105, 107
<i>Trichosomum</i>	117
<i>verrucosum</i>	102
<i>Trichostrongylus</i>	14, 47, 86-87 , 88, 90, 91, 92, 94, 96
<i>capricola</i>	14, 87, 96-98 , 122
<i>colubriformis</i>	14, 87, 90 , 122
<i>extenuatus</i>	14, 17, 82, 87, 94-96 , 108, 121, 122, 123
<i>instabilis</i>	14, 87, 88-89 , 90, 92, 96, 122, 123, 124
<i>probolurus</i>	14, 87, 90-92 , 122, 123, 124
<i>retortæformis</i>	86
<i>subtilis</i>	88
<i>vitrinus</i>	14, 87, 92-94 , 96, 122, 123, 124
<i>Trichurinæ</i>	15, 20, 23, 110, 111 , 117
<i>Trichuris</i>	15, 16, 17, 20, 21, 111-112 , 114, 115, 116
<i>alcocki</i>	15, 112, 115 , 123
<i>cameli</i>	15, 111, 116-117 , 123
<i>discolor</i>	15, 111, 114 , 121
<i>giraffæ</i>	15, 111, 117 , 123
<i>globulosa</i>	15, 112, 115-116 , 123
<i>ovis</i>	15, 112-114 , 121, 122, 123
<i>trichiura</i>	111
<i>Tricocephalus</i>	111
<i>trifurcata</i> , <i>Ostertagia</i>	14, 55, 62 , 63, 122
<i>trigonocephalum</i> , <i>Bunostomum</i>	27, 30
<i>trigonocephalus</i> , <i>Monodontus</i>	14, 21, 28-31 , 122
<i>Strongylus</i>	28
<i>tumida</i> , <i>Capillaria</i>	117
<i>Uncinaria cernua</i>	30
(<i>Monodontus</i>) <i>cernua</i>	30
<i>radiata</i>	31
<i>Ungulata</i>	121
<i>ventricosus</i> , <i>Strongylus</i>	14, 47, 98-99 , 123
<i>Strongylus</i>	71, 73, 77, 99
<i>venulosum</i> , <i>Cesophagostoma</i>	46
<i>Cesophagostomum</i>	14, 41, 46-47 , 49, 122, 123

	Page.
<i>venulosus, Strongylus</i>	46
<i>verrucosa, Filaria</i>	104
<i>Spiroptera</i>	14, 102, 103, 104 , 123
<i>Spiroptera</i>	102
<i>verrucosum, Gongylonema</i>	14, 17, 100, 102 , 121, 122
<i>Trichosomum</i>	102
<i>vicarius, Strongylus</i>	59, 62
<i>vitrinus, Trichostrongylus</i>	14, 87, 92-94 , 96, 122, 123, 124
<i>vituli, Ascaris</i>	25
<i>vitulorum, Ascaris</i>	13, 17, 25 , 121
<i>vryburgi, Agriostomum</i>	14, 18, 27 , 121
<i>wedlii, Monodontus</i>	30

